MUSCULOSKELETAL SYSTEM[1]

I. INTRODUCTION

A. OUTLINE OF HIGHLIGHTED CONDITIONS

Neck:
1) Cervical Pain, Radiculopathy, and Instability

Back:
2) Lumbar Pain, Radiculopathy, and Disc Surgery
3) Spondylolisthesis
4) Scoliosis
5) Miscellaneous Back Abnormalities

Knee:
6) Meniscus Injuries
7) Loose Body in the Knee
8) Patellofemoral Problems
9) Anterior Cruciate Ligament Instability
10) Collateral Ligament Instability

Upper Extremity:
11) Acromioclavicular Separation
12) Shoulder Subluxation and Dislocation
13) Finger Amputations/Arthrosis

Miscellaneous:
14) Retained Hardware
15) Leg Length Discrepancy

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[1]Author: R. Leonard Goldberg, M.D.
Specialist Review Panel:
Neck/Back - Stanley Bigos, M.D.; Vert Mooney, M.D.; James Stark, M.D.
Knee - Dale Daniel, M.D.; James Garrick, M.D.; James Stark, M.D.
Upper Extremities/Misc. - David Levine, M.D.; Phillip Sobol, M.D.

B. IMPLICATIONS FOR JOB PERFORMANCE

Abnormalities in the musculoskeletal system may limit an officer's ability to perform numerous essential tasks such as:

- Running in pursuit of suspects for distances up to 500 yards. Speed is important in up to 90% of incidents.
- Balancing and walking several yards at 6-10 feet above ground on top of walls or other surfaces which are frequently only 6" wide.
- Climbing 6' fences, 2-5 flights of stairs, 20' ladders, and 36' embankments where speed is required 33% of the time.
- Jumping/hurdling/vaulting across 3-5' ditches, down from 6' walls, and over 3' shrubs. Speed is required 90% of the time. One-third of these events occur from a stationary position.
- Moving incapacitated persons without assistance for distances averaging 40'. Speed is critical in 40% of instances.
- Pushing vehicles, dragging and pulling objects averaging 60 lbs. without assistance where speed is required 50% of the time.
- Crawling/crouching/squatting
- Subduing combative subjects
- Firearm and weapon handling which includes the ability to use batons, resist take-away attempts by suspects, and to maintain stability of the arm and wrist despite recoil forces of up to 48 lbs. (shotguns).

II. MEDICAL EXAMINATION AND EVALUATION GUIDELINES

A. GENERAL SCREENING RECOMMENDATIONS

1) History: The physician should obtain the following information for each incidence of musculoskeletal injury:

- Circumstances of the Injury: How did the injury occur, and did it result in a personal injury or workers' compensation award? The physician must try to assess the contribution of litigation to protracted treatment periods or disability.

- Dates of Injury, First Symptom, First Treatment, Last Symptom, Last Treatment, Last Evaluation: When injuries result in litigation, these dates are often very different and can yield important clues as to the true severity of the injury. For example, it is not uncommon for whiplash victims to have symptoms which begin 1-2 days after the accident as muscle spasm and inflammation develop. Symptoms that develop immediately may indicate a more severe injury. Those that develop at one week or more may have resulted from a visit to a lawyer's office rather than from the accident. The date of first treatment may also provide similar clues. The physician should ask for the date of last symptom and the date of last treatment in separate questions. The candidate must explain any discrepancy of more than 2-3 weeks. It is not uncommon, especially in personal injury cases, for candidates to report that treatment lasted for months after they became asymptomatic. Medical record review will usually reveal that the candidate reported symptoms for the length of treatment. Unless the candidate resolves this discrepancy to the satisfaction of the examiner, more credibility should be placed on the written medical records.

  The hiring agency should be informed if the candidate admits falsifying information to a previous health care provider in an attempt to defraud an insurance company or former employer. This information may have relevance in the agency's background investigation of the candidate.

  Finally, the physician should ask the candidate if there have been any evaluations subsequent to the termination of treatment. These may have been performed as part of either a permanent disability determination or a pre-placement evaluation by another agency.

- Extent of Disability: What was the impact of the injury or pain on the candidate? Were there limitations in sitting, standing, lifting, or walking? How many days of work were lost? How long were work restrictions necessary? Did the candidate return to the same work duties? Did the candidate work despite the presence of pain? Was the candidate awarded permanent disability? What was the impact of the injury on the candidate's participation in sports? Are there any current symptoms or residual impairment of functional ability?

- Problems Since Recovery: Have there been any recurrences of pain or other problems since the recovery period?

2) Examination: A thorough musculoskeletal examination on every candidate, regardless of history, would be quite time-consuming. Alternatively, an adequate screening exam for candidates with a negative history could consist of the following components:

   - Inspection of all joints for scars or obvious atrophy.

   - Upper Extremity: Range of motion, apprehension test for shoulder instability, and grip strength.

   - Back: Heel/toe walk, forward flexion, inspection, palpation, and passive straight leg raise.

   - Knees: Duck walk and squat (note any difficulty or asymmetry), inspection (note any scars, atrophy of the medial vastus obliquus muscle, or effusion), measure bilateral thigh circumference at 10 cm. proximal to the patella with active straight leg raising (note differences >1/2"), test for anterior cruciate and collateral ligamentous laxity at 30 degrees of flexion, screen for patellar apprehension, and have the candidate perform a one-legged hop bilaterally (normal symmetry is +/-15%). More detail regarding these tests are provided in the recommended evaluation protocols for the knee conditions, or by reviewing Henning, et al. (1986).

3) Routine Testing: No routine testing of the musculoskeletal system is recommended for candidates who have a negative history (this includes physical ability testing and x-ray examination). However, the physician should be aware that POST requires that all patrol officer recruits successfully complete a physical work sample test before graduation from a certified academy.

B. EVALUATION OF COMMON CLINICAL SYNDROMES

1) CERVICAL PAIN, RADICULOPATHY, AND INSTABILITY

a. GENERAL CONSIDERATIONS:

Certain soft-tissue and bony abnormalities of the cervical spine can result in sudden neurological compromise of the extremities if the neck is jarred or forced into hyperextension or flexion. If this occurs during a critical incident, the safety of the officer and the public could be in jeopardy. Consequently, the physician must attempt to identify those candidates who pose a significantly increased risk. This can be a difficult task, given the following statistics:

- 35% of the population has a history of neck pain and 10% have had neck pain associated with arm pain (Wiesel, 1989);

- 85% of all neck injuries are due to a motor vehicle accident and many result in litigation (Wiesel, 1989);

- Among those who deny a history of neck pain, 35% of 40-45 year-olds and 75% of 50-55 year-olds will have radiographic evidence of degenerative changes (Gore, et al., 1986);

- MRI will show evidence of either a herniated or bulging disc in 10% of persons who deny a history of neck pain (Boden, et al., 1990a).

In summary, neck complaints are common, their duration is often biased by non-physical factors, and poor specificity limits the usefulness of radiographic information.

Given these considerations, guidelines for recommending restrictions must be based on criteria with the highest possible specificity. Although not an exhaustive list, these criteria include any of the following:

- Current EMG Evidence of Neuropathy: The EMG provides the most specific evidence that cervical pathology has clinical significance. A minority of these candidates may have demonstrable impairment, such as loss of grip strength. In others, it is reasonable to assume that cervical stress during a critical incident (for example, due to sudden forced flexion/extension) could exacerbate the neuropathy, and result in acute impairment. EMG findings of concern would include the observation of more than one positive sharp wave or fibrillation potential, or a significant H-reflex delay.

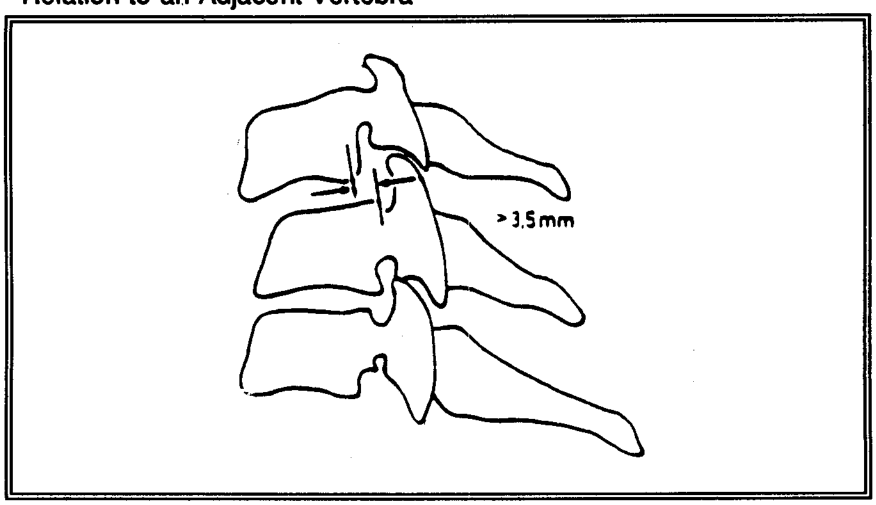
- Current Limitation of Activity: Many patients find that heavy lifting or other activities significantly aggravate their neck pain (Wiesel, 1989). Such limitations are likely to interfere with the candidate's ability to perform patrol officer duties.

- Current Cervical Instability: In the normal cervical spine, horizontal displacement between vertebrae does not exceed 3.5 mm (Figure VIII-1) and angular differences do not exceed 11 degrees (Figure VIII-2) even when measured at extremes of flexion and extension (White, et al., 1975). Stability can be disrupted by cervical fractures or severe disruption of the posterior ligaments. It is generally recognized that instability creates a substantial risk of catastrophic neurological compromise if sudden stress is placed on the neck (as could occur when subduing a combative arrestee). Therefore, candidates with abnormal instability should be referred for surgical arthrodesis (Micheli, 1985). Fusion of the cervical spine is not considered a contraindication to neck trauma if the segments above and below the level of fusion are mechanically stable (Micheli, 1985).

- History of Cervical Laminectomy without Fusion: Even if performed with minimal exposure, destabilization of the spine significantly increases the risk of catastrophe with neck trauma (Micheli, 1985).

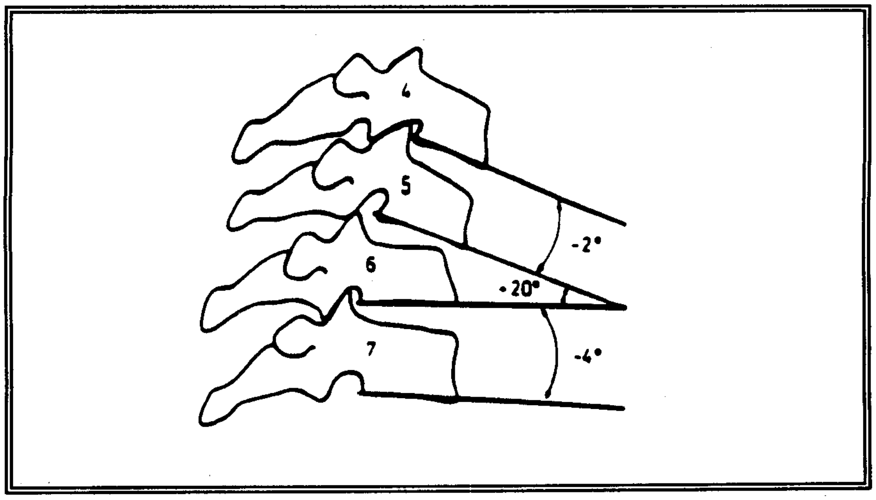
- History of Temporary Traumatic Para or Quadriplegia: Despite subsequent solid arthrodesis and restoration of neurologic function, most surgeons would restrict activities involving neck trauma in these candidates (Micheli, 1985).

FIGURE VIII-1
Horizontal Displacement Greater than 3.5 mm of One Vertebra in Relation to an Adjacent Vertebra



Reproduced with permission from White A.A., et al. 1975. Biomechanical analysis of clinical stability in the cervical spine. Clin Orthop Rel Res. 109:85-96.

FIGURE VIII-2
Rotational Difference Between Adjacent Vertebra



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b. RECOMMENDED EVALUATION PROTOCOL:

For the purposes of this protocol, the history must be sufficiently thorough to establish the extent to which the candidate has experienced periods of:

- Isolated Neck Pain With No Apparent Functional Significance: Candidates deny any limitation or restriction in work, daily activities, or sports.
- Radicular Symptoms: Defined as symptoms or signs in the arm distal to the shoulder. These are suggestive but not diagnostic of neural compromise.
- Limitation of Activities: May be secondary to either impairment, avoidance, or restriction. The physician must keep in mind that assessing activity levels in the post-morbid state is always biased by the pre-morbid activity level. For example, it is much more likely that an active candidate will report a history of activity limitation, compared to a sedentary candidate.

Medical record review is highly recommended to confirm the candidate's history, especially when litigation was involved. The results of any previous diagnostic test, such as an MRI, CT, or EMG should be obtained.

The physician should perform a thorough neck examination which includes range of motion, palpation, and neurological screening for evidence of radiculopathy. Range of motion should be performed with the neck in neutral position and full extension.

GROUP I: NO HISTORY OF FRACTURE/DISLOCATION AT ANY TIME, AND NO LIMITATIONS OR RADICULAR SYMPTOMS IN THE LAST THREE YEARS

No restrictions or further evaluation (including radiographs) can be justified unless the physical exam detects abnormalities.

GROUP II: NOT MEETING CRITERIA FOR GROUP I

Obtain lateral flexion/extension and bilateral oblique radiographs. Consider ordering an EMG in the following circumstances:

- Limitations that lasted for 3 months or more, or
- Radicular symptoms that lasted for 1 month or more, or
- Radiographic evidence of neural compression, such as marked narrowing of foramen on the oblique radiograph or displacement of neural elements observed on MRI or CT scan, or
- Physical exam results suggesting current neuropathy.

Any of the following major findings would indicate that restrictions against subduing arrestees are justified to reduce a direct threat to either the candidate or others:

- Most recent EMG is consistent with a neuropathy due to cervical pathology;
- Current neck or arm complaints involving limitations of activity;
- Current cervical instability on the basis of flexion and extension radiographs;
- History of cervical laminectomy without fusion;
- History of temporary/traumatic para or quadriplegia.

In general, chronic non-limiting cervical pain that is EMG-negative is not considered sufficiently dangerous to warrant work restrictions. However, for the pain to be considered non-limiting, the candidate should be currently participating in activities that are equivalent in intensity to that required of patrol officers.

In certain cases of very recent neck pain, temporary deferral (never to exceed three months) may be justified by the need to determine the course of the condition and to allow complete healing of stretched ligaments. The severity and duration of the pain and the candidate's current activity level should be major determinants of the length of the deferral period.

2) LUMBAR PAIN, RADICULOPATHY, AND DISC SURGERY

a. GENERAL CONSIDERATIONS:

Many of the considerations discussed above for the cervical spine apply to the evaluation of the lumbar spine. This evaluation focuses primarily on assessing the risk of sudden incapacitation during a critical incident involving such lumbar-stressing activities as carrying an unconscious person, pushing a 3,000 lb. car, jumping down from a 6 foot wall, or subduing an arrestee. Certain candidates are at substantially increased risk of acute neurological compromise of a leg (Weber, 1990), or more commonly, an incapacitating acute spasm of the lumbar musculature.

An additional consideration with regard to lumbar spine injuries is the frequent occurrence of chronic disability that often develops after a patrol officer incurs an on-duty back injury. The only study available found that 9/42 (21%) of back-injured patrol officers remain on restricted duty for three months or longer (Sullivan, 1991). Whether due to the nature of patrol officer duties, or the availability of generous compensation, this rate of chronic disability appears to be much greater than the 5% reported for the general population (Anderson, et al., 1983). For many agencies, accommodating a three-month or greater period of disability may represent undue hardship, as well as interfere with protecting public safety.

Similar to those with cervical problems, the identification of candidates who are either at significantly increased risk of sudden incapacitation or who have a >50% probability of developing chronic disability is difficult due to the following considerations:

- Back pain is a part of life: 60-90% of the population will experience low back pain at one time or another (Kelsey & Golden, 1988), and 40% will have sciatica at some point in time (Frymoyer, et al., 1983);
- A specific anatomical diagnosis is made in only 12-15% of cases (Rowe, 1969);

- Despite the risk of chronic disability, as cited above, a back injury in a patrol officer typically results in less than two weeks of restricted duty. In fact, the median time off is only 4 days (Sullivan, 1991);

- Radiographic surveys of patients >40 years old who deny a history of back pain have found prevalence rates of degenerative changes as high as 50% (Magora & Schwartz, 1976);

- MRI and CT scanning will show disc herniations in about 20% of patients who have no history of back pain (Boden, et al., 1990b; Wiesel, 1984).

Given these considerations, guidelines for recommending restrictions or deferral periods must be based on criteria with the highest specificity possible.

To prevent sudden incapacitation during a critical incident, the following criteria are suggested for assigning restrictions to candidates with < Grade III spondylolisthesis or <45 degree scoliosis (see later sections for evaluation of these specific conditions):

- <u>Current EMG Evidence of Neuropathy</u>: The EMG provides the most specific evidence that lumbar pathology has current clinical significance. A minority of these candidates may have demonstrable impairment, such as leg weakness. In others, it is reasonable to assume that stress to the back during a critical incident could exacerbate the neuropathy and result in acute impairment. EMG findings of concern would include the observation of greater than one positive sharp wave or fibrillation potential, or a significant H-reflex delay.

- <u>Current Limitation of Activity</u>: Many patients find that heavy lifting, prolonged sitting, or other activities significantly aggravate their lumbar pain. Such limitations are likely to interfere with the candidate's ability to perform patrol officer duties.

- <u>History of Multi-Level Laminectomy Without Fusion</u>: This procedure greatly disturbs the mechanics of the spine and indicates markedly abnormal underlying connective tissue disease.

A separate set of criteria was developed to identify candidates who should be temporarily deferred due to a high risk (>50% chance) of chronic disability within the immediate future (0-3 years). "Chronic disability" was defined as restricted duty for at least a 3-month period. This definition was based not only on the undue hardship considerations mentioned above, but also on the observation that these patients have a 25% probability of never returning to unrestricted work (Waddell, 1990).

Numerous studies have examined the predictive value of a multitude of risk factors, such as previous back pain, age, back weakness, poor cardiovascular fitness, smoking, and severe multiple disc degeneration (see Bigos, et al., 1990 for summary). Making reliable conclusions from the literature is difficult due to differences in outcome parameters and poor control of confounders, such as occupational and recreational activity levels. Additionally, many risk factors, such as muscle weakness and prior back injury, are highly intercorrelated (Nordgren, et al., 1980). With this in mind, the following criteria are recommended as the basis for deferring certain candidates:

- Recent Episode of Back Pain that Resulted in at Least Three Months of Activity Limitation: Several studies have shown that the recurrence rate for back pain is about 50-60% within the first year (Bergquist-Ullman & Larsson, 1977; Troup, et al., 1981; Biering-Sorensen, 1984). Although these studies looked at the recurrence rate of any back pain (rather than specifically chronic pain or activity-limiting pain), it is not unreasonable to assume that a history of chronic limiting pain creates a 50-60% probability of recurrence of a pain of similar severity and duration. Using this assumption, these candidates should be restricted from high-risk activities, such as very heavy lifting, pushing, pulling, and wrestling, until they have been asymptomatic for at least 12 months following an episode of chronic limiting back pain.

- Recent Lumbar Disc Surgery: Although there are numerous types of surgeries for herniated discs, all are associated with substantial risks of recurrent or chronic pain and disability. In a review of 2,500 surgeries, Taylor (1989) found that 40% of patients did not achieve complete pain relief. In a review of 19 studies, Spangfort (1972) found that an average of 23% of patients were not able to return to their original level of employment. However, in the vast majority of cases, recurrent pain will occur within the first post-surgical year (Weber, 1983).

  When post-surgical patients do return to work, their risk of serious injury is substantially increased. Based on a small prospective study of postal workers, Ryan and Zwerling (1990) found that the back injury rate of new employees who had recent back surgery was six times higher than normal. Additionally, a back injury in this population resulted in either repeat surgery or retirement in 50% of eight cases. The median lost time was 66 days, compared to 8.5 days for back injuries in other employees. These considerations would strongly support deferral of post-surgical candidates until they have resumed intensive occupational or recreational activities, without limitations, for at least 6-12 months.

b. RECOMMENDED EVALUATION PROTOCOL:

The history must be sufficiently thorough to establish the extent to which the candidate has experienced periods of:

- Isolated Lumbar Pain With No Apparent Functional Significance: Candidates deny any limitation or restriction in work, daily activities, or sports.

- Radicular Symptoms: Defined as symptoms or signs in the leg distal to the buttocks. These are suggestive but not diagnostic of neural compromise.

- Limitation of Activities: May be secondary to either impairment, avoidance, or restriction. The physician must keep in mind that assessing activity levels in the post-morbid state is always biased by the pre-morbid activity level. For example, it is much more likely that an active candidate will report a history of activity limitation compared to a sedentary candidate.

Medical record review to confirm the candidate's history is highly recommended, especially when litigation was involved. The results of any previous diagnostic test, such as an MRI, CT, or EMG, should be obtained.

Candidates with a history of low back pain should have a complete back examination which includes the tests described under General Screening Recommendations plus range of motion, measurement of leg lengths (see Leg Length Discrepancy), and a complete neurological examination of the lower extremities.

GROUP I: NO HISTORY OF LUMBAR DISC SURGERY, LIMITATIONS, OR RADICULAR SYMPTOMS IN THE LAST THREE YEARS

No restrictions or further evaluation (including radiographs) can be justified unless the physical exam detects abnormalities.

GROUP II: NOT MEETING CRITERIA FOR GROUP I

Obtain straight lateral and bilateral oblique radiographs if there is a history of chronic or recurrent pain in the last three years. If prior radiographs exist, an attempt should be made to obtain and use them, since a spine series involves a significant amount of radiation.

Consider ordering an EMG in the following circumstances:

- Limitations that lasted for 3 months or more, or

- Radicular symptoms that lasted for 1 month or more, or

- Radiographic evidence of neural compression, such as marked narrowing of foramen on the oblique radiograph or displacement of neural elements observed on MRI or CT scan, or

- Physical exam results suggesting current neuropathy.

Any of the following major findings would indicate that restrictions against heavy lifting, jumping, and subduing combative arrestees are justified:

- Most recent EMG is consistent with a neuropathy due to lumbar pathology;

- Current symptoms which limit activity;

- History of multi-level laminectomy without fusion.

In general, chronic non-limiting lumbar pain which is EMG-negative is not considered sufficiently dangerous to warrant restrictions. However, for the pain to be considered non-limiting, the candidate should be currently participating in activities/sports that are equivalent in intensity to that required of patrol officers.

Temporary deferral (never to exceed 12 months) may be justified in cases of:

- Recent episode of back pain that resulted in at least 3 months of activity limitation;

- Recent lumbar disc surgery.

3) SPONDYLOLISTHESIS

a. GENERAL CONSIDERATIONS:

Spondylolisthesis is the most common cause of back pain in adolescence and is usually due to stress lysis (spondylolysis) of the posterior arch at L5. If anterior slippage of L5 occurs, it is graded as follows:

Grade I - 25% or less
Grade II - 26-49%
Grade III - 50-75%
Grade IV - >75%

Slippage generally does not progress significantly after skeletal maturity, except occasionally in cases of high-grade (Lonstein, 1987b) or L4 slips (Saraste, 1987).

Typically, the primary symptom is constant back pain which is aggravated by carrying heavy loads or taking long walks. Radicular symptoms may occur with more severe slips due to stretching of nerve roots over the posterior sacral body. Disc prolapses are rare because the posterior ligament is drawn taut and prevents posterior bulging (Wiltse, 1971). Severe slips may cause a back deformity manifested by increased lordosis and hamstring tightness (Akbarnia & Keepler, 1989).

Spondylolysis and Grade I or II spondylolisthesis do not appear to be major risk factors for lumbar disability (Semon & Spengler, 1981; McCarroll, et al., 1986; Apel, et al., 1989; Friberg, 1987). However, despite a paucity of literature, there is a general consensus that slips of 50% or more have an exceedingly poor prognosis. In fact, some experts advocate surgery on adolescents with Grade III slips even if asymptomatic (Lonstein, 1987b). In one of the larger studies of high-grade slips, Harris and Weinstein (1987) followed eleven Grade III and IV patients for 18 years. Only four patients were asymptomatic; the others either had symptoms, muscle atrophy, hyporeflexia, or avoided heavy lifting.

The degree of slippage is usually assessed with a standard lateral radiograph. Instability demonstrable on routine flexion/extension views does not correlate with symptoms and does not contribute significant information (Pearcy & Shepherd, 1985; Stokes & Frymoyer, 1987; Saraste, 1987).

b. RECOMMENDED EVALUATION PROTOCOL:

When there is a history of spondylolisthesis, the physician should perform a complete back examination which includes the tests described under General Screening Recommendations, plus range of motion, as well as a complete neurological examination of the lower extremities. A recent cone-down lateral radiograph must be obtained in order to use the protocol below.

GROUP I SPONDYLOLISTHESIS <50%

This does not represent a significant risk factor. Evaluate as per the recommended evaluation protocol in "Lumbar Pain, Radiculopathy, and Disc Surgery."

GROUP II SPONDYLOLISTHESIS 50% OR MORE

In most cases, these candidates should be restricted from heavy lifting and wrestling to prevent chronic pain (Watkins & Dillin, 1990). However, the physician should consider making exceptions in rare cases of candidates in their late twenties or thirties who have a documented record of heavy exertion over a number of years without significant back pain or radiculopathy. These candidates should also not have tight hamstrings, limited spinal motion, obesity, weak abdominal muscles, or neurological findings on exam.

4) SCOLIOSIS

a. GENERAL CONSIDERATIONS:

Scoliosis is of concern due to the potential for chronic pain, radicular symptoms, and restriction of lung volumes.

Scoliosis often causes activity-related aching and fatigue due to muscle pain, facet joint arthrosis, or degenerative disc disease (Lonstein, 1987a). A major determinant of the amount of pain is the degree of the curve. As a group, patients with curves <45 degrees do not have an increased incidence of pain (Kostuik & Bentivoglio, 1981; Winter, 1987). With larger curves, most will have some pain. In a cross-sectional study of a non-patient population, Kostuik and Bentivoglio (1981) found that 7/8 scoliotics with curves of 45 degrees or more had pain. Three individuals had pain of moderate severity that resulted in occasional lost time at work and regular use of analgesics. Two other individuals were disabled from severe pain. This study also found that, in general, scoliotics in physically demanding jobs were less able to cope, missed more time from work, and were more likely to be incapacitated.

The location of the curve is also important. Pain is rare in scoliosis limited to the thorax compared to lumbar or thoracolumbar curves (Lonstein, 1987a).

Approximately 2% of scoliotics have radicular symptoms due to nerve root entrapment from facet joint hypertrophy and/or vertebral spur encroachment into the foramen (Kostuik, 1980). However, facet joint sclerosis on radiograph does not generally result in a significant increase in the probability of pain (Kostuik & Bentivoglio, 1981). Cord compression is not a complication of idiopathic scoliosis (Lonstein, 1987a).

Cardiopulmonary symptoms due to chest wall deformity can occur, especially in scoliotics with curves >40 degrees (Ascani, et al., 1986).

Curve progression is discussed extensively in the literature, since curves that are progressing tend to be more painful, and progression may be an indication for surgery in patients < age 35, even if they are asymptomatic (Kostuik, 1990). However, after skeletal maturity, curves <30 degrees generally do not progress, and those that are larger progress very slowly on average. Thoracic curves >50 degrees progress an average of 1 degree/year, while others progress an even lesser amount (Weinstein & Ponseti, 1983; Ascani, et al., 1986). Due to the difficulty of accurately measuring angles, a diagnosis of curve progression requires a change of at least 10 degrees.

Scoliosis may be treated by means of bone grafting or internal fixation devices. These procedures will usually decrease and stabilize the curve (Edgar & Mehta, 1981). The risk for continued lumbar pain, acute injury, secondary upper thoracic and cervical pain, and functional difficulties with stressful activities depends on the number of non-mobile segments and the location of the fusion. Fusions of 2-3 segments are not associated with an increased risk of acute injuries, but pursuit of vigorous activities will cause long-term deterioration due to increased mechanical stress immediately above or below the fused portions of the spine. However, most spinal surgeons would strongly advise patients with fusions of 4 segments or more to avoid heavy contact sports, such as rugby or football, due to an elevated risk of acute injury (Micheli, 1985).

Many studies have found that the distal extent of the fusion is a major risk factor for residual lumbar pain (Edgar & Mehta, 1981). Cochran, et al. (1983) reported pain in approximately 20% of patients with fusion ending at L2, 40% at L3, 60% at L4, and 80% at L5. Several studies have found that the incidence of pain is higher in the presence of degenerative changes (Edgar & Mehta, 1981; Kostuik, et al., 1973).

Extensive fusions, such as those associated with Harrington rods, can also cause functional difficulties. Dickson, et al. (1990) found that 45% of patients treated with rods had at least some difficulty with sitting, sports, carrying, and lifting.

b. RECOMMENDED EVALUATION PROTOCOL:

In candidates with a history of scoliosis, the physician should specifically inquire about any signs of curve progression, such as decreasing height or increasing dorsal hump on flexion. A thorough exercise history involving both recreational and occupation stressors to the back is very important.

A complete back examination should be performed which includes the tests described under General Screening Recommendations, plus range of motion, as well as a complete neurological examination of the lower extremities. Spirograms should be performed on all candidates, especially those with curves of 45 degrees or greater. Spirogram evaluation guidelines are found in the Respiratory Chapter.

Medical record review is strongly recommended. Previous back radiographs are useful if assessment of progression is important. The best view to assess curve angles is a full-length (3 feet) spinal x-ray. Details regarding measurement of scoliosis can be found in Morrissy (1990).

GROUP I: CURVE <45 DEGREES

Evaluate per guidelines in "Lumbar Pain, Radiculopathy, and Disc Surgery."

GROUP II: CURVE ≥45 DEGREES

Level 1: No history of radiculopathy at any time and no limitation of recreational or occupational activities in the last year

If age <35 and there has been significant curve progression after adolescence (i.e. >10 degrees), the candidate may require surgery and should therefore be deferred until seen by an orthopedist. However, the probability of progression is not high enough to warrant deferral during a prospective observation period.

Candidates should be deferred if they are not currently stressing their backs at a level equivalent to that required by patrol officers since most will develop moderate-to-severe pain with these activities. Those who can demonstrate that they can tolerate heavy activities with no more than mild discomfort do not warrant deferral or restriction.

Level 2: Does not meet criteria for Level 1

These candidates should be restricted from heavy lifting and wrestling since they are either at increased risk of sudden incapacitation from nerve root traction and/or are likely to become disabled from patrol officer activities.

GROUP III: HISTORY OF SURGERY

Candidates with a history of spinal fusion should have a flexion-extension radiograph to evaluate the fusion, and a CT to examine neural elements and the patency of the canal (Micheli, 1985). In questionable cases, an EMG may be necessary.

Level 1: Less than 4 segments fused

Candidates who have either:

- Residual positive neurological signs or symptoms;
- Unstable fusions;
- Compression of neural elements documented by EMG; or
- Loss of 30% of the neural canal

are probably at substantial risk of serious injury from patrol officer activities. In all cases, a deferral for at least 12 months post-op is necessary to ensure complete healing (Micheli, 1985).

Level 2: Fusion of 4 segments or more

In addition to the factors identified in Level 1, the physician should consider the following risk factors:

- Extension of the fusion to L3 or below,
- Radiographic evidence of degenerative changes above or below the fusion,
- Secondary cervico-thoracic pain, or
- An activity level not equivalent to patrol officer duties.

A candidate with any of these risk factors can develop frequent and limiting pain with heavy lifting, pushing, pulling, and wrestling, and should therefore be restricted.

5) MISCELLANEOUS BACK ABNORMALITIES

There are numerous lumbar spine abnormalities, often discovered on routine radiographs, which have no prognostic value and, generally, should be ignored:

- Tropism, or misorientation of the facet joints;
- Increased lumbar lordosis (Hult, 1954; Splittoff, 1953; Horal, 1969);
- Lumbosacral tilt (Horal, 1969; Hult, 1954);
- Spina bifida occulta (Wiltse, 1971);
- Transitional vertebrae (Wiltse, 1971);
- Schmorl's nodes.

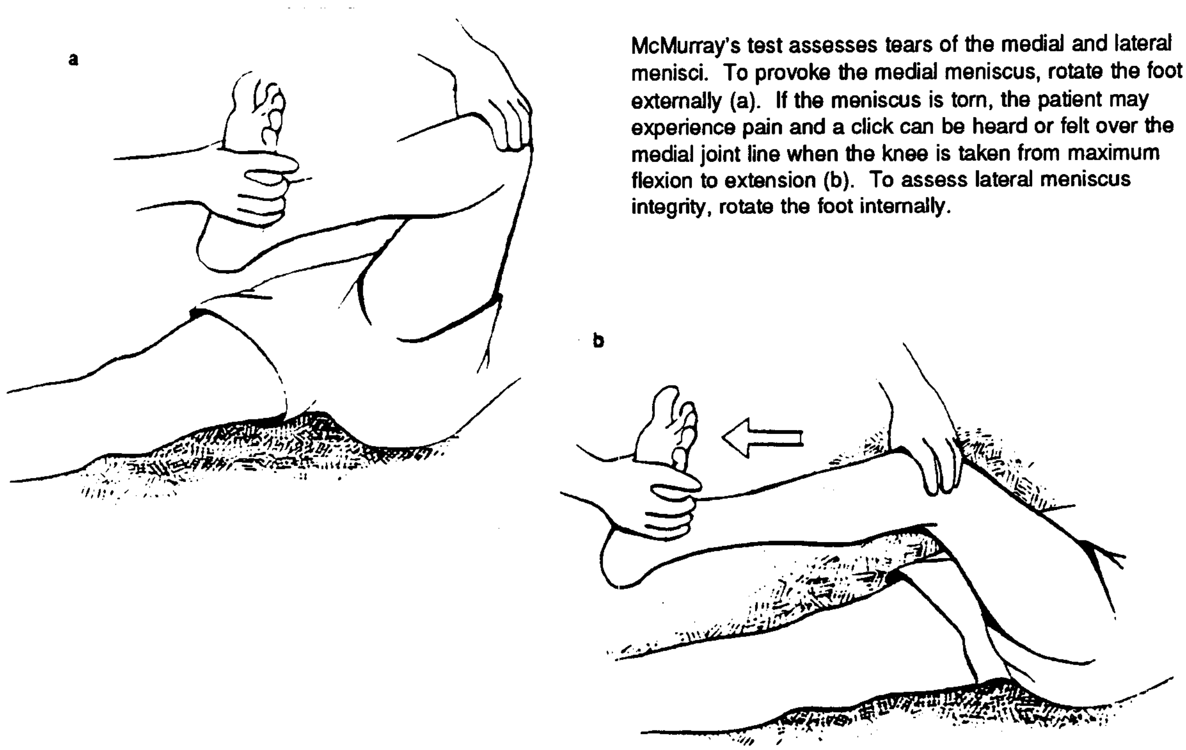
6) MENISCUS INJURIES

a. GENERAL CONSIDERATIONS:

A torn meniscus typically causes the knee to suddenly lock. Secondary pain may also cause the knee to suddenly give way (Henning, et al., 1986). If either occurs during a critical incident, the safety of the officer and the public could be jeopardized. Consequently, in most cases, the presence of a torn meniscus would clearly require a work restriction. Exceptions may be made in candidates >40 years old who may have tears secondary to degenerative changes rather than trauma. These generally do not cause locking.

The diagnosis is suspected if there is a history of locking, giving way, or joint line pain. On examination, classic findings include joint line tenderness and a positive McMurray's sign (Figure VIII-3). The diagnosis is confirmed with either an MRI scan, arthrogram, or arthroscopy.

FIGURE VIII-3
McMurray's Test



McMurray's test assesses tears of the medial and lateral menisci. To provoke the medial meniscus, rotate the foot externally (a). If the meniscus is torn, the patient may experience pain and a click can be heard or felt over the medial joint line when the knee is taken from maximum flexion to extension (b). To assess lateral meniscus integrity, rotate the foot internally.

Berg, E., Henderson, J.M. and Simon, R.R. 1990. Office diagnosis of knee pain. Patient Care. 24:48-78. Reproduced with permission from Patient Care, September 30, 1990. Copyright (c) Medical Economics Publishing, Montvale, NJ.

The MRI scan has been shown to be very accurate for diagnosing meniscal tears. Radiologists generally grade the tear on a scale of I-III. Grade I represents intrameniscal signal changes without tear. A grade II change represents a linear intrameniscal signal not extending to the superior or inferior meniscal surface. On arthroscopy, approximately 17% of these menisci will be found to be torn (Fischer, et al., 1991). If a high-powered 1.5 tesla magnet is used, a grade III tear will be confirmed by arthroscopy in 80-90% of cases (Fischer, et al., 1991; Polly, et al., 1988; Wirth, et al., 1990).

The MRI has limited usefulness in two groups of patients: (1) older individuals; and (2) those who complain of recurrent symptoms after repair of a tear. In older patients, the clinical significance of observed changes is uncertain, since degeneration has been found to occur naturally with age. In those who have undergone meniscal repair, the MRI cannot accurately differentiate between old scarring and a recurrent tear. The MRI does not become "normal" even in successful patients. Consequently, these patients must be evaluated with either an arthrogram or arthroscopy.

Depending on the extent and location, a meniscal tear can be managed either non-operatively, with surgical repair, or by removal (partial or complete). Conservation of as much of the meniscus as possible is the goal, since total removal leads to later problems in most patients. For example, in a study of 180 Navy officers, Veth (1985) found that, after 5 years, 72% had at least one of the complaints shown in Table VIII-1. Forty percent of the officers had at least two of the complaints numbered 6-14. Jorgensen, et al. (1987), who studied 131 athletes, found that 53% were symptomatic and 10% had instability after five years. After an additional ten years, 67% were symptomatic, 36% had instability, and 89% had radiographic degenerative changes. As a consequence, 46% had given up or reduced their sporting activity, and 6.5% had changed their occupation. A poor outcome was likely if the patient had at least one complaint in addition to radiographic changes when examined at five years post meniscectomy.

In the immediate post-surgical period, physical therapy is very important to ensure muscle rehabilitation. Most surgeons do not allow agility drills, squatting, or full-speed running until after three months following excision and six months following repair (DeHaven & Sebastianelli, 1990; Henning, 1990).

TABLE VIII-1
Post-Operative Complaints in Patients Who Are Treated by Meniscectomy

1. Stiffness of knee
2. Swelling of knee
3. Pain at rest and/or motion
4. Feeling of instability
5. Loss of strength associated with knee movements
6. Giving way
7. Normal participation in sports and/or hobbies impossible
8. Disability climbing/descending stairs
9. Disability kneeling
10. Disability squatting
11. Disability walking on uneven surfaces
12. Inability to perform the same occupation as preoperation
13. Change of occupation due to post-meniscectomy symptoms
14. Locking

From Veth, R.P.H. 1985. Clinical significance of knee joint changes after meniscectomy. Clin Orthop Rel Res. 198:56-60. Reprinted by permission of the publisher.

b. RECOMMENDED EVALUATION PROTOCOL:

For the candidate who reports a history of meniscal tear, the physician should inquire regarding any of typical complaints found in Table VIII-1. Details regarding any surgical treatment and subsequent rehabilitation should be noted.

In addition to the knee exam described in General Screening Recommendations, the candidate should be given a complete examination of both knees which includes the following:

- Range of Motion: With the patient supine and knees flexed, note any differences in heel to thigh distances. With the patient prone, knees fully extended and feet hanging beyond the table, note any differences in heel height. In both measurements, a centimeter difference represents a 1 degree loss of range of motion. A significant deficit is considered to be present when the knee cannot be flexed to at least 120 degrees, or there is an extension deficit of 10 degrees or greater (Mohtadi, et al., 1991).

- McMurray's Test: See Figure VIII-3.

An AP and lateral radiograph is useful in establishing the extent of degenerative changes. The AP film should be obtained in the standing position if possible.

Record review is generally not necessary unless there is evidence of cruciate ligament (AP) laxity or a history of post-recovery symptoms.

In general, a candidate with normal examination results should be considered acceptable after resuming vigorous activity for at least a three-month period without significant symptoms. This recommendation is made regardless of the original pathology or treatment. However, in questionable cases in which activity or symptomatic status is in doubt, it is appropriate to give some consideration to objective prognostic factors, such as the extent of meniscus excision, the amount of time since the tear occurred (prognosis worsens with time elapsed), and the presence of degenerative changes on radiograph.

Evidence of significant muscle atrophy, muscle weakness, or loss of motion warrants a referral to a physical therapist for further assessment and possible rehabilitation. Either abnormality can limit peak performance during a critical incident and substantially increase the risk of patellofemoral pain (see Patellofemoral Problems).

Candidates with a positive McMurray's should be re-evaluated by an orthopedist and have an arthrogram or arthroscopy if there is any doubt regarding the current status of the meniscus.

7) <u>LOOSE BODY IN THE KNEE</u>

A cartilaginous or bony fragment can cause sudden locking or giving way due to pain. If either occurs during a critical incident, the officer's and the public's safety could be jeopardized. The risk of locking is considered to be significant if there is a prior history of locking or if the loose body is >5 mm in size.

In the candidate population, loose bodies are most commonly discovered on knee radiographs as incidental findings. With the initial set of films, it is often difficult to determine whether the object is adherent to other structures and, therefore, not of concern. Repeat radiographs after walking are very helpful and should show movement of the object if it is a true loose body.

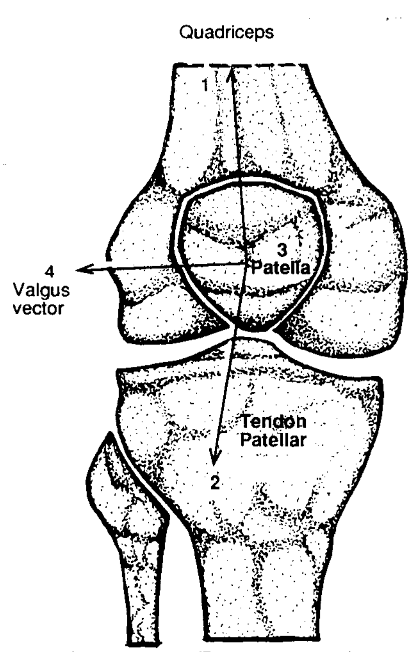
If a loose body is confirmed, the candidate should be restricted from running and wrestling until it is removed. Exceptions could be granted if prior radiographs document that the loose body has been present for a number of years and the candidate has been asymptomatic.

8) PATELLOFEMORAL PROBLEMS

a. GENERAL CONSIDERATIONS:

The patella and the patellar ligament transmit the extension force of the quadriceps to the proximal tibia. The normal medial "bowing" or valgus of the leg creates a "Q" angle between the quadriceps ligament above and the patellar ligament below the patella (Figure VIII-4). This results in a force vector which pulls the patella laterally.

FIGURE VIII-4
The Q Angle Imposes a Lateral Vector on the Terminal Degrees of Extensor Movement



Reproduced with permission from Fulkerson, J.P., and Hungerford, D.S. eds. 1990. Disorders of the Patellofermoral Joint. 2nd ed. Baltimore: Williams & Wilkins.

In the normal knee, this lateral force is opposed by a combination of static and active stabilizers. The static stabilizers consist primarily of the medial peripatellar retinaculum and the femoral groove or trochlea between the femoral condyles. The primary active stabilizer is the medial component of the quadriceps, the vastus medialis obliquus (VMO).

Normal patellar tracking can be summarized as follows: At full extension, the patella is slightly proximal and lateral to the trochlear groove. Between 0-20 degrees of flexion, the patella is smoothly and gradually drawn into the groove and is well-seated by 30 degrees. The dynamics of this movement require a perfect balance between the lateral force vector and the medial stabilizers.

When this balance is disturbed, excessive lateral tilt and/or movement of the patella can cause excessive pressure on the lateral patellofemoral joint surfaces, lateral subluxation of the patella, and in extreme cases, dislocation. The resultant abnormal forces result in the eventual destruction of the joint cartilage (chondromalacia) and reactive/degenerative changes in the affected bones (arthrosis).

Clinically, patients complain of anterior knee pain, especially when the knee is loaded on hills or stairs. The pain is thought to be due primarily to abnormal stretching of the peripatellar ligaments (Fulkerson & Hungerford, 1990). Subluxation commonly causes sensations of giving way and may cause a patient to stop activity, at least temporarily (Eisele, 1991). Actions that typically precede subluxation include decelerating while walking downstairs, running, jumping, or twisting while putting weight on the affected leg. Subluxation can lead to frank dislocation at any time, even with trivial injuries (Fulkerson & Hungerford, 1990). Dislocation is a dramatic and severe injury which always causes at least temporary incapacitation.

On examination, patients will often show "apprehension" when the examiner presses laterally on the patella with the knee flexed at 30 degrees. There may be obvious atrophy in the VMO or less firmness on contraction compared to the opposite side.

With the development of severe chondromalacia and arthrosis, patients may also complain that prolonged sitting with the knees flexed (as in a theater or car) causes pain, and pseudo-locking or a gelling sensation on attempting to straighten the knee under load (Garrick, 1989). With severe arthrosis, sensations of giving way are commonly caused by sudden reflex relaxation of the quadriceps due to severe pain. This may occasionally lead to a fall. Sometimes patients complain of "catching," thought to be due to irregular joint surfaces (Fulkerson & Hungerford, 1990).

In considering a candidate with a history of chondromalacia, keep in mind that:

- The diagnosis of chondromalacia is commonly given to any young athlete with activity-related anterior knee pain based on history alone. This is often erroneous, as the diagnosis requires arthroscopic or MRI visualization of the chondral surface. Pain is more commonly due to malalignment and retinacular stretching.

- There are numerous rating systems for chondromalacia. The most widely used is that proposed by Outerbridge (1961):

  Grade I - softening and swelling
  Grade II - fragmentation and fissuring <1/2" in diameter
  Grade III - fragmentation and fissuring >1/2" in diameter
  Grade IV - erosion of cartilage to bone

- Chondromalacia does not directly cause pain since cartilage is not innervated. Numerous studies have shown a poor correlation between the degree of chondromalacia and pain. However, as the chondral "shock absorber" is worn away, abnormal stress to the innervated subchondral bone will cause pain. Goodfellow, et al. (1976) has stated that surface changes do not cause patellofemoral pain unless bone is exposed in an area of habitual patellofemoral contact.

Patellofemoral malalignment and secondary pain/instability can be caused by any factor that increases the lateral force vector on the patella or weakens the medial stabilizers. Examples include: a high riding patella (patella alta), hypoplastic femoral groove, increased "Q" angle between the femur and tibia due to excessive leg valgus or foot pronation, a high insertion angle of the VMO, or weakness of this muscle. However, the most common cause is thought to be excessive tightness of the lateral peripatellar retinaculum.

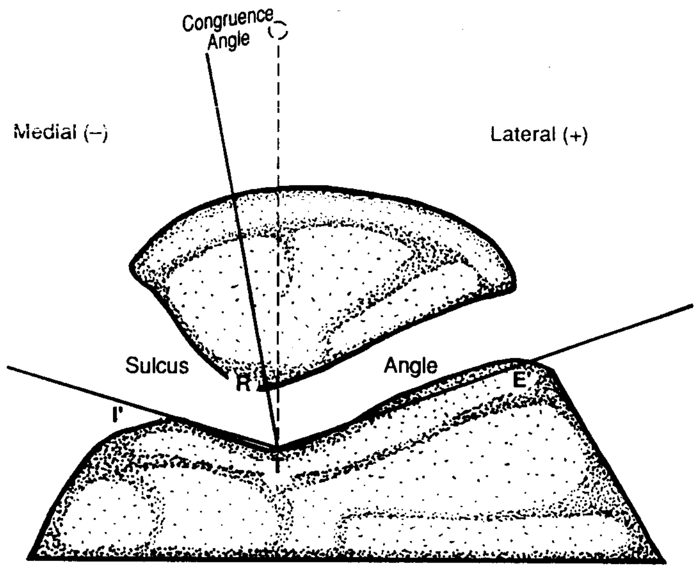
Ideally, conservative treatment should attempt to correct the specific underlying cause of the malalignment. More commonly, most physicians generically recommend temporary reduction in activities, VMO strengthening, NSAIDS, and use of a knee sleeve to reduce any lateral tracking. The majority of cases do not require surgery. When surgery is necessary, the most common procedure involves cutting the lateral retinaculum (lateral release).

After initially observing that this procedure was frequently unsuccessful, numerous studies were conducted to improve patient selection and outcome. The results have shown that patients will generally have a good to excellent outcome if they (a) have documented tightness of the retinaculum before surgery (Gecha & Torg, 1990; Kolowich, et al., 1990), and (b) undergo sufficient post-op rehabilitation to eliminate radiographically documented lateral patellar tilt and excessive lateral position (Dzioba, 1990; Simpson & Barrett, 1984; Scuderi, et al., 1988).

Dzioba's study clearly documented that rehabilitation was critical for a successful outcome. Radiographs of all patients at 10 days post-op showed no improvement. However, after six weeks of therapy, 44 patients had normal tilt and position; 9 others were abnormal. Three to four years later, 42/44 in the successful rehab group were rated good to excellent. In the other group, all nine patients were still significantly limited in activity and had considerable pain with squatting, kneeling, or prolonged stair climbing. Three of these patients required further surgery.

The radiographic view used in the Dzioba study and many others is a 45 degree patellar axial view originally described by Merchant, et al. (1974). Patellar position is quantified by measurement of the "congruence angle" (Figure VIII-5) between a line that bisects the femoral sulcus angle (line TO) and a line from the bottom of the patella to the lowest point in the femoral groove. Merchant found that normal congruence is -6 degrees, with 95% of normals having an angle of <+16 degrees. Patellar tilt can be evaluated by measurement of the lateral patellofemoral angle of Laurin, et al. (1984; Figure VIII-6). This angle should be open laterally. Laurin recommended that this angle be measured at 20 degrees, but this is technically very difficult. The 45 degree axial view is a good screening test, but is subject to errors due to projectional angles and overlapping shadows. Moreover, many patients with malalignment may have normal position at 45 degrees, but maltracking at 10-30 degrees (Schutzer, 1986a).

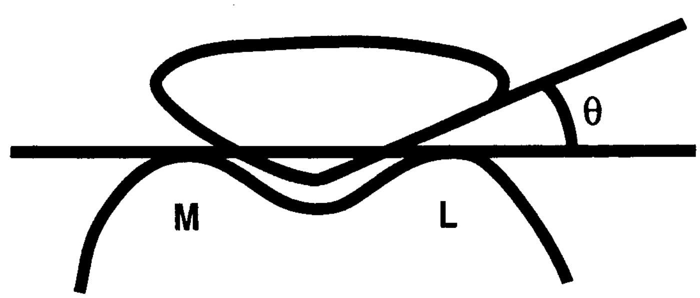
FIGURE VIII-5
Measurement of Congruence Angle



Normal congruence angle = (-) 6 degrees. Ninety-five percent of normals have angles < (+) 16 degrees.

TO, Neutral Reference Line Bisecting Angle E'TI'. RT, Line Connecting Median Ridge to Trochlear Depth. Adapted with permission from Merchant, A.C., et al. 1974. Roentgenographic analysis of patellofemoral congruence. J Bone Jt Surg. 56A:1391-1396.

FIGURE VIII-6
Lateral Patellofemoral Angle



The lateral patellofemoral angle (θ) of Laurin should open laterally (L). This measurement is helpful in screening patients for patellar tilt.

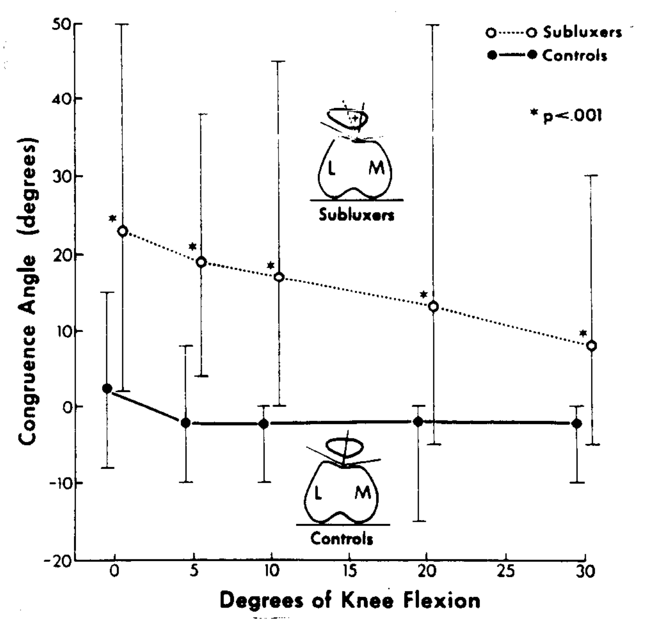
Reproduced with permission from Fulkerson, J.P., and Hungerford, D.S. eds. 1990. Disorders of the Patellofemoral Joint. 2nd ed. Baltimore: Williams & Wilkins.

Patellar CT has been proposed as the optimal method for evaluating the patello-femoral joint because axial images can be obtained during the initial degrees of knee flexion. Typically, scans are made at 0, 15, 30, 45, and 60 degrees at a cost not much greater than ordinary knee radiographs. Normal alignment is defined as a congruence angle of 0 or negative at 15 degrees of flexion (Schutzer, 1986b). Figure VIII-7 indicates expected congruence throughout the range of motion. CT is also much better than ordinary films for measurement of the tilt angle. This angle should always be >7 degrees, and generally has been 12-14 degrees or more at 15-20 degrees of knee flexion in asymptomatic control knees (Schutzer, 1986b).

MRI scanning is useful for examining the extent of chondromalacia. Recently, kinematic MRI scanning has been used to dynamically measure patellar tracking. Compared to CT, this offers the advantage of revealing excessive medial subluxation that is common in post lateral release patients (Shellock, et al., 1989). However, the clinical significance of this has not been established.

It should be noted that the use of knee sleeves to reduce lateral tracking is problematic for patrol officers, since they tend to bunch up and become uncomfortable with prolonged sitting in the patrol car.

FIGURE VIII-7
Patellar CT Measurement of Congruence Angles in Subluxers and Controls



There are many patellofemoral pain patients whose patellae are *relatively* subluxed when compared to controls.

Reproduced with permission from Schutzer, S.F., Ramsby, G.R., Fulkerson, J.P. 1986b. Computed tomographic classification of patellofemoral pain patients. Orthop Clin North Am. 17(2):235-248.

b. RECOMMENDED EVALUATION PROTOCOL:

Candidates with a history of anterior knee pain, patellar subluxation, or patellar dislocation should be carefully questioned regarding the frequency and recency of these symptoms. The physician should specifically inquire about giving way, falling, sensations of instability, and gelling of the knee after prolonged sitting.

The screening knee exam described in the General Screening Recommendations should be augmented to include the following:

- Palpation of the peripatellar retinaculum and soft tissues for tenderness;

- Observation of patellar tracking during active extension of the tibia from 90 to 0 degrees of flexion with the candidate seated.

NOTE: The patellar apprehension sign may stay positive for many years after an episode of instability. Therefore, it cannot be used to indicate a current propensity to dislocate. Its primary usefulness is as a general screening tool for those who deny a history of patellar instability.

All candidates should have 45-degree Merchant axial views of both patellae. The lateral patellar femoral tilt angle of Laurin and Merchant's congruence angle should be measured (see Figures VIII-5 and VIII-6).

All medical records should be obtained and reviewed.

In general, physicians can safely conclude that candidates who meet all of the following guidelines do not warrant further evaluation or work restrictions:

HISTORY:

- Participation at an activity level equivalent to academy training for at least six months with no more than occasional mild pain which did not affect performance or warrant treatment, doctor visits, or use of braces. Any sensation of instability would require further evaluation.

- No subluxation or dislocation for the past two years if conservatively treated, or none for the past year if a lateral release or other realignment procedure was performed.

- No history of documented Grade IV chondromalacia.

EXAMINATION:

- Normal bulk and firmness of VMO
- Normal quadriceps size and function (hop test)
- No tenderness
- Patella smoothly exits from the femoral sulcus at 10-20 degrees of flexion, then moves slightly laterally in the last few degrees of extension. There is no abruptness of patellar movement.

RADIOGRAPH:

- Tilt angle is open laterally.
- Congruence angle at 45 degrees is <+16 degrees.
- Presence of arthrosis is limited to mild degrees of subchondral sclerosis.

Candidates who do not meet these guidelines may be acceptable after a deferral period, or if found to have normal tracking by patellar CT or MRI. In deciding whether to restrict or defer these candidates, the physician should give more consideration to the history, current activity level, and lower extremity function than to radiographic abnormalities, since the clinical specificity of abnormal tilt, congruence angles, and degenerative changes is unknown. The following is presented to assist the physician in typical cases:

- <u>Current or Recent Evidence of Subluxation/Dislocation</u>: This condition substantially increases the risk that the candidate may be suddenly impaired during a critical incident either due to falling, or cessation of activity due to pain or instability. Therefore, these candidates warrant restrictions against field duties.

- <u>Patellar Tilt Without Subluxation</u>: This condition may increase the risk of pain with forced extension during running, stair climbing, and lifting. However, this may not be severe enough to impede an officer during a critical incident. Chronically, it may lead to chondromalacia and arthrosis, but this process takes much longer than two years.

- <u>Grade IV Chondromalacia/Moderate-to-Severe Arthrosis</u>: These conditions increase the risk of pain with forced extension during running, stair climbing, and lifting. Pain and gelling may occur after prolonged sitting in a patrol car. However, this will probably not be severe enough to impede an officer during a critical incident. The best justification for restricting these candidates is the possibility of giving way due to reflex pain. However, this is quite uncommon except in the most severe cases which are characterized by virtual obliteration of the patellofemoral joint space on radiograph. If this is not present, or if there is no history of giving way, it is difficult to justify restricting candidates who are active and otherwise acceptable.

- VMO or Quadriceps Atrophy: Unless the candidate has an exceptional athletic history, a referral to a physical therapist for further assessment and possible rehabilitation is warranted. As discussed above, muscle weakness increases the risk of patellofemoral pain.

9) ANTERIOR CRUCIATE LIGAMENT INSTABILITY

a. GENERAL CONSIDERATIONS:

Of all the knee ligaments, the anterior cruciate ligament (ACL) is the most important to knee function. Its primary role is to prevent excessive anterior subluxation of the tibia during high stress activities such as pivoting, cutting, and jumping. Without the stabilization of the ACL, the knee is at significantly increased risk of giving way (GW) which could result in sudden incapacitation during critical incidents. The ACL is also important in a wide range of other patrol officer activities, such as walking on uneven ground and squatting (Tables VIII-2-3; Hirshman, et al., 1990).

TABLE VIII-2
Specific Task Performance (Percentage) in ACL-Disrupted Patients, 5 Years Since Injury*

Task	No Problem	Mild Impairment	Moderate Impairment	Unable To Do
Getting out of chair	100	0	0	0
Prolonged standing	76	21	3	0
Walking	94	6	0	0
Walking on uneven ground	65	35	0	0
Ascending stairs	85	15	0	0
Descending stairs	88	12	0	0
Climbing	71	29	0	0
Kneeling or squatting	56	44	0	0
Jogging	71	23	0	6
Running fast	63	19	6	12
Jumping	66	22	3	9
Twisting or pivoting	53	35	3	9
Cutting	50	29	3	18

*Study performed at San Diego Kaiser; N=34. From Hirshman, H.P., et al. 1990. The fate of unoperated knee ligament injuries. Chap. 27 in Knee Ligaments: Structure, Function, Injury and Repair. eds. D.M. Daniel, et al. Reprinted by permission of the publisher.

TABLE VIII-3
Pain, Swelling, and Giving Way in Chronic ACL Patients During Activities of Daily Living

Author	Number of Patients	Pain-- More Than Mild or Infrequent	Swelling-- More Than Infrequent	Giving Way	Years of Average Follow-Up	Remarks
McDaniel, 1980	49	38%	10%	Not reported for ACL	14	
Noyes, 1983	103	30%	14%	21%	5.5	Selected population of "worst cases"
Hawkins, 1986	40	18%	18%	11%	4	30% who underwent reconstruction not included
Hirshman, 1990	34	0%	0%	9%	5	

From Hirshman, H.P., et al. 1990. The fate of unoperated knee ligament injuries. Chap. 27 in Knee Ligaments: Structure, Function, Injury and Repair. eds. D.M. Daniel, et al. Reprinted by permission of the publisher.

Although many patients return to full athletic activity after an ACL tear, an equal or greater number are unable to do so without significant limitations (Table VIII-4; Hirshman, et al., 1990). Recurrent GW and injury are very common. Sandberg, et al. (1987) observed that 17% will have GW within 13 months after injury. Others have found that 43-88% of these patients will ultimately have trouble with GW (McDaniel & Dameron, 1980; Fetto & Marshall, 1980; Hawkins, et al., 1986; Finsterbush, et al., 1990). Therefore, many orthopedists believe that young athletes who wish to maintain a high competitive ability should have the ligament repaired.

There are five basic approaches to the treatment of a torn ACL -- conservative care and four surgical options. In general, the surgical techniques attempt to create a check-rein, either internally or externally, to limit anterior tibial translocation. *Primary repair* involves direct suturing of the ends of the torn ligament. *External augmentation* attempts to reduce GW by relocating a strip of the iliotibial band to create a lateral "sling" (see Figure VIII-8). *ACL reconstruction* involves using a graft tissue to replace the ruptured ACL. The typical graft source is the central part of the patella tendon or a strip of the semitendinosus or gracilis tendon. The surgeon attempts to position the graft in the anatomical location of the ACL inside the joint (see Figure VIII-9). Recently, some surgeons have advocated a fourth approach which involves the combined use of *external augmentation with ACL reconstruction.*

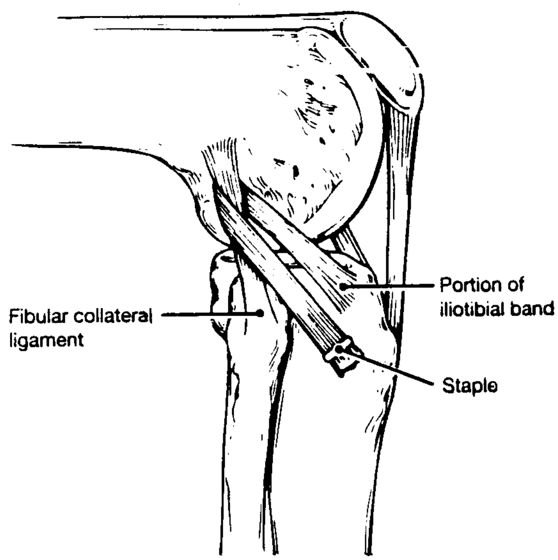
TABLE VIII-4
Sports Activity in Patients with Nonoperative Treatment of Isolated ACL Injuries

Author	Sports Participation	Remarks
Chick, 1978	17% not capable of "full athletic activity"	Excluded patients with moderate or severe anterior instability
McDaniel, 1980	In 58%, the knee restricted or limited sports activity	Little detail on sports functions
Giove, 1983	31% did not return to full preinjury level of participation; 87% had significant signs or symptoms	Patients involved in "heavy participation" sports did less well
Noyes, 1983	35% in strenuous sports, but only 11% without limitation	Only symptomatic patients were included in this study
Walla, 1985	42% in high-intensity sports with limitations; only 14% in same sports at same level	
Satku, 1986	54% did not play preinjury sports	Few details about sports
Fowler, 1987	22% in pivoting sports with activity moderation; 17% uninhibited in pivoting sports	All patients were symptomatic
Hirshman, 1990	47% not playing preinjury sport; only 31% playing without hindrance	

From Hirshman, H.P., et al. 1990. The fate of unoperated knee ligament injuries. Chap. 27 in Knee Ligaments: Structure, Function, Injury and Repair. eds. D.M. Daniel, et al. Reprinted by permission of the publisher.

Although current surgical techniques can reduce the risk of recurrent GW, they do not eliminate it. Furthermore, many patients continue to have problems with swelling, pain, and recurrent injuries. A sample of representative studies are presented in Table VIII-5 to illustrate this point. Of the surgical approaches available, most orthopedists currently believe that primary repair is probably not much better than conservative care. External augmentation does not appear to be very successful either. ACL reconstruction has the best chance for reducing the probability of GW and poor results.

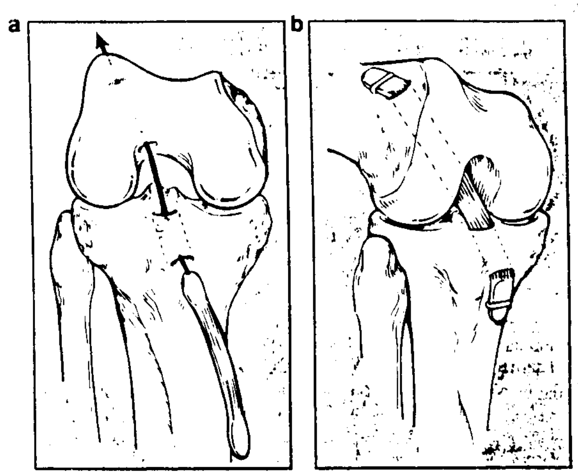
FIGURE VIII-8
Extra-Articular Anterior Cruciate Ligament Reconstruction Using the Arnold-Coker Iliotibial Band Technique



A strip of iliotibial band is detached proximally and wrapped around the fibular collateral ligament. This procedure can be done with a staple, as shown, or with sutures when a youth's epiphysis is still open.

Reproduced with permission from Nisonson, B. 1991. Anterior cruciate ligament injury. Phy Sports Med. 19(5):82-89.

FIGURE VIII-9
Intra-Articular Reconstruction After Anterior Cruciate Ligament Injury



Repair uses a strip of patellar tendon and its attached bone, shown (a) before placement through drill holes (arrow indicates path) and (b) in its final position.

Reproduced with permission from Nisonson, B. 1991. Anterior cruciate ligament injury. Phy Sports Med. 19(5):82-89.

TABLE VIII-5
Summary of ACL Repair Studies

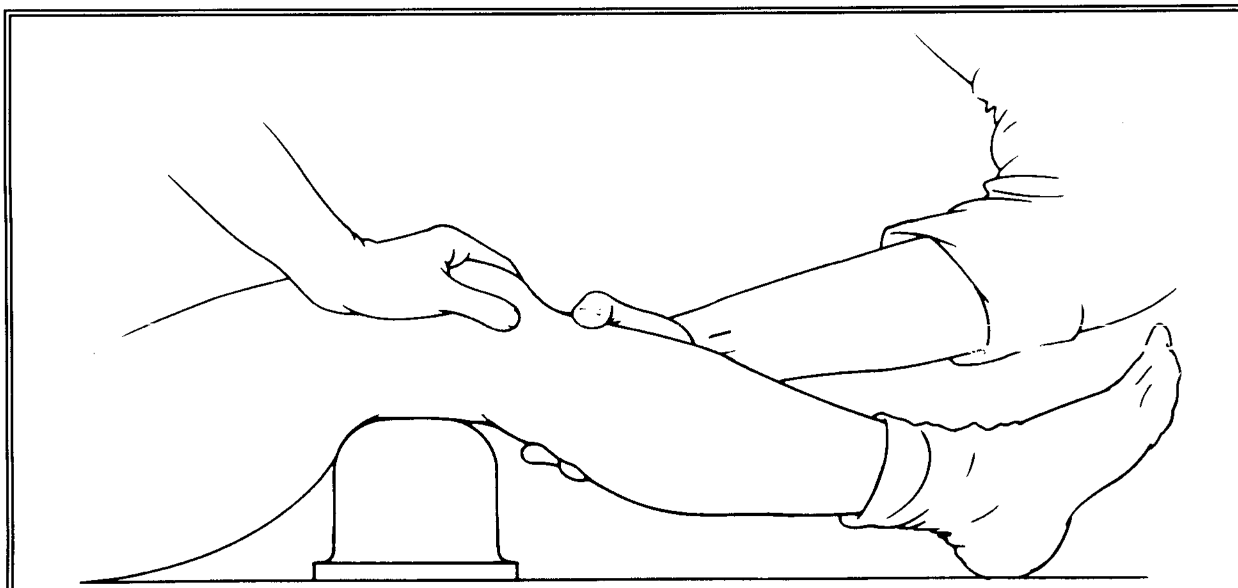
Surgical Technique	Results	Follow-Up period (n)
Primary Repair:		
Feagin 1976	94% instability 55% reinjury rate	5 yr (32)
Kaplan 1990	48% restricted sports 17% failures	7 yr (52)
Sherman 1991	22% fair-poor 18% reinjured	5 yr (50)
Odensten 1984	43% fair-poor	5 yr (35)
Strand 1984	18% had GW	4 yr (60)
External Augmentation:		
Amirant 1988	48% fair-poor	11 yr (27)
Bray 1988	45% unsatisfactory	6 yr (47)
Warren 1978	35% had GW	6.4 yr (17)
Larsen 1991	29% had GW	3 yr (21)
Dahlstedt 1988	67% unsatisfactory	6 yr (39)
ACL Reconstruction:		
O'Brien 1991	5% had GW	4 yr (80)
Johnson 1984	31% fair-poor	8 yr (87)
Noyes 1990	11% fair-poor 2% had GW	3 yr (47)
Shelbourne 1990	6% had instability	4 yr (140)
Noyes 1991	16% had GW	3 yr (64)
Marder 1991	10% had GW	2 yr (80)
Howe 1991	5% had GW 21% unsatisfactory	5.5 yr (83)
ACL Reconstruction Plus External Augmentation:		
Noyes 1991	0% had GW 3% "failure" rate	3 yr (40)
Wilson 1990	0% had GW 7% fair	2-7 yr (32)
O'Brien 1991	No better than reconstruction alone	4 yr (?)
Sgaglione 1990	No better than reconstruction alone	3 yr (51)

Given these considerations, the physician must carefully evaluate all candidates with a history of ACL tear. The typical candidate will deny any current symptoms or functional problems and claim to be athletic. However, despite their apparent subjective success, some of these candidates remain at substantially increased risk of a GW episode in a critical incident, or may have significant functional impairments. The challenge to the physician is to objectively make this determination on an individual basis. To do so requires consideration of the major risk factors for the occurrence of GW and/or functional impairment. These major risk factors include:

1. MORE THAN MINOR INSTABILITY: Instability due to ACL insufficiency is usually quantified in one of four ways. [Note: the injured knee should always be compared to the contralateral normal knee.]

   a) Lachman Test: This is the simplest and most sensitive clinical test for instability (Figure VIII-10). With the extremity in slight external rotation and the knee held in 15-20 degrees of flexion, the femur is stabilized with one hand and firm pressure is applied to the posterior aspect of the proximal tibia, lifting it forward in an attempt to translate it anteriorly. Excessive anterior excursion compared to the opposite knee, or a lack of firm end point are indicative of a positive test. It is customary to report the amount of anterior tibial translation in grades I to IV which increase in 5 mm increments.

FIGURE VIII-10
The Lachman Test



To facilitate patient relaxation, stabilize the femur, and control the joint flexion angle, the patient lies supine with the thigh supported in 20-30° of flexion.

From Dale Daniel, M.D. Reproduced with permission from the author.

b) Anterior Drawer: This classic test, performed with the knee at 90 degrees of flexion, has a sensitivity of only about 33-54% (Zelko & Abrams, 1982; Donaldson, et al., 1985; Jonsson, et al., 1982). Like the Lachman, this test is graded in 5 mm increments.

c) Pivot Shift: Most orthopedists believe this maneuver to be the most specific for GW since it can demonstrate rotatory instability in addition to anterior instability (Figure VIII-11). Traditionally, the finding of rotatory instability indicated a significantly increased risk of GW. However, recent biomechanical studies have discounted the importance of the rotatory component. The major limitations of the pivot shift are its poor sensitivity compared to the Lachman (Donaldson, et al., 1985; Hawkins, et al., 1986), and the technical difficulty involved in performing the test, even for experienced orthopedic surgeons (Noyes, 1991). The pivot shift is usually graded on a three or four point scale: I = mild slipping, II = moderate slipping, and III = clunking, locking or dislocation.

FIGURE VIII-11
Flexion-Rotation Drawer Test (A Method of Demonstrating a Pivot Shift)

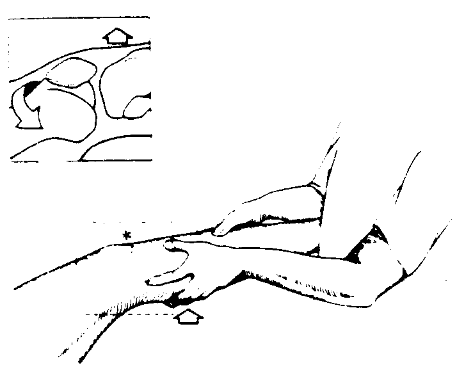


Figure A

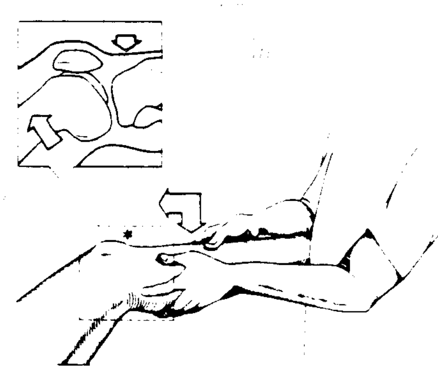


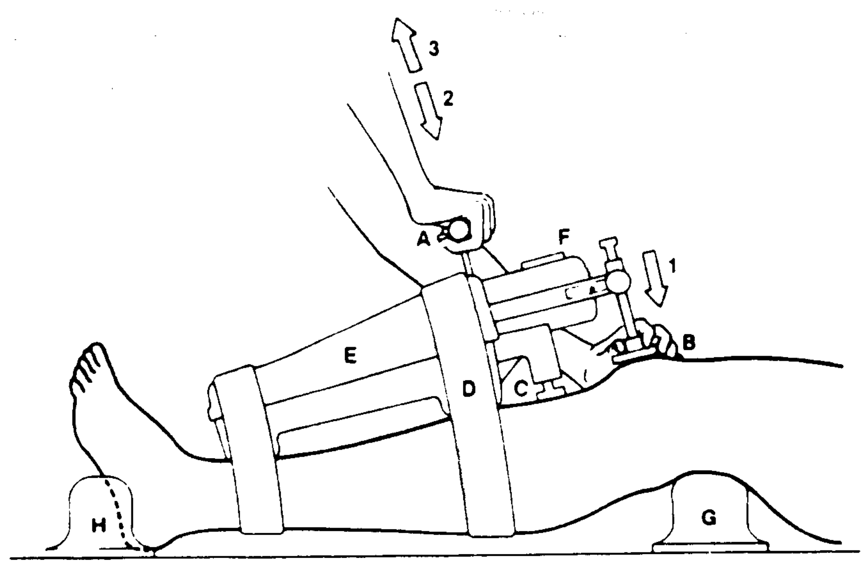
Figure B

A. Flexion-rotation drawer test, subluxated position. With the leg held in neutral rotation, the weight of the thigh causes the femur to drop posteriorly and rotate externally, producing anterior subluxation of the tibia.
B. Flexion-rotation drawer test, reduced position. Gentle flexion and a downward push on the leg reduces the subluxation. The test is graded: 0 = no shift, 1+ = slight shift, 2+ = moderate shift, and 3+ = momentary locking.

From Noyes, F.R., et al. 1980. Arthroscopy in acute traumatic hemarthrosis of the knee. J Bone Jt Surg. 62A(5):687-695, 757.

d) Arthrometer: Due to the difficulty of performing and quantifying laxity with manual testing, considerable research has been conducted to validate instrumented testing. The most commonly used arthrometer is the KT-1000 (Figure VIII-12). With the knee fixed at 25 degrees of flexion, the device allows the operator to apply a measured amount of anterior force to the tibia. This maneuver is identical to the manual Lachman test, but has the advantage of allowing the examiner to read the amount of displacement from the device. Typically, both knees are tested at 15 lbs., 20 lbs., 30 lbs., and at maximal manual force. Side-to-side differences are computed, as well as the increased displacement between 15 and 20 lbs., or between 20 and 30 lbs. (compliance index).

FIGURE VIII-12
KT-1000 Test



The limbs are supported with a thigh and foot rest (G, H). The arthrometer is placed on the anterior aspect of the leg and held with velcro straps (D). Two sensor pads: one in contact with the patella (B) and the other in contact with the tibial tubercle (C) move freely in the anterior-posterior plane in relation to the arthrometer case (E). The instrument detects the relative motion in millimeters between the two sensor pads and, therefore, motion of the arthrometer case does not affect the measurement which is displayed on the dial (F). Displacement loads are applied through a force sensing handle (A). A tone indicates when a 15 and 20 lb. displacement force is applied. With adequate stabilization of the patella in the femoral trochlea, tibial tubercle motion relative to the patella accurately reflects the motion of the tibia relative to the femur.

Figure VIII-13 illustrates the expected results in normal vs. ACL-deficient knees (Daniel & Stone, 1990).

The KT-1000 results appear to be fairly accurate and reproducible. Studies using one examiner have found that 90-95% of repeat measurements of both individual knee displacement and side-to-side differences fall within an average range of +/-2 mm (Steiner, et al., 1990; Wroble, et al., 1990; Daniel & Stone, 1990). Different examiners can be expected to produce average group results which differ by about 10-15% (Forster, et al., 1989; Daniel & Stone, 1990).

The KT-1000 arthrometer (produced by MedMetric, San Diego) is not very expensive but does take practice. Many physical therapists perform the test for a relatively low charge.

It is common for candidates with a history of ACL tear to have some degree of demonstrable instability, even if the ligament has been repaired. The difficulty lies in determining the point at which this instability creates a significantly increased risk of sudden incapacitation, or makes it probable that the candidate either has or will develop functional limitations in the near future:

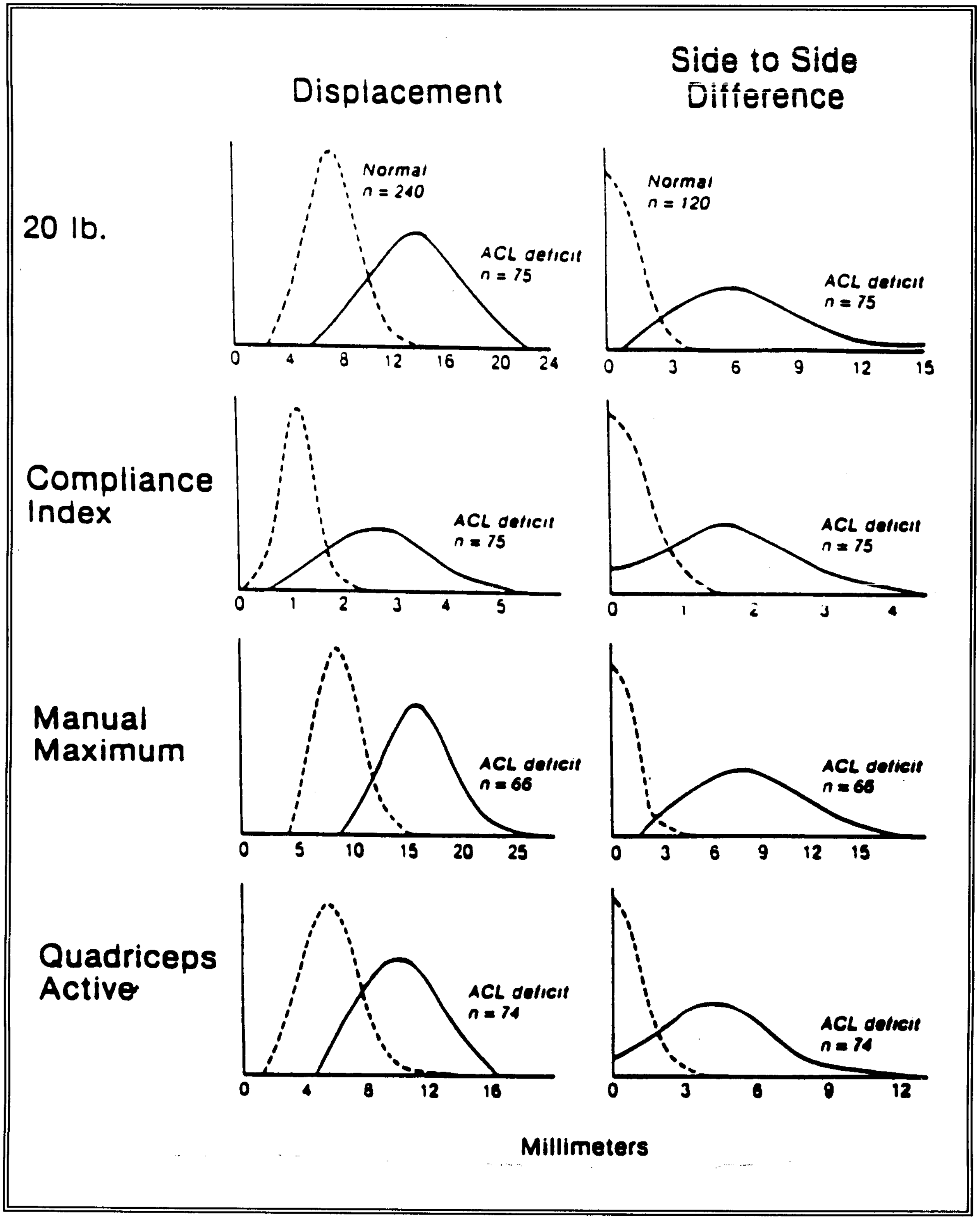
- Lachman Test: There are no studies that correlate the findings on this test with risk of GW.

- Anterior Drawer: One study found that the prevalence of GW was 26% in 11 patients with a 1+ anterior drawer and 73% in 38 patients with >1+ drawer (Warren & Marshall, 1978).

- Pivot Shift (PS): Many orthopedists believe that a positive test is a troubling finding. If the results of four studies are combined, 81% of 94 patients with a (+)PS had problems with GW (McDaniel & Dameron, 1980; Chick & Jackson, 1978; Lysholm, 1982; Strand, et al., 1984). However, based on their clinical experience, it was the opinion of the panel members that the PS should be at least of Grade II magnitude if it is to be used to justify work restrictions.

- Arthrometer: Several studies have found that a side-to-side difference of >5 mm on the KT-1000 test indicates clinically significant instability and poor prognosis. For example, Sherman, et al. (1991) found that 7/10 patients who met this criterion were rated as clinical objective failures within five years of follow-up. The best data regarding clinical significance are found in Daniel and Stone (1990). As part of a long-term follow-up study of 173 consecutive

FIGURE VIII-13
KT-1000 Measurements



Anterior Displacement Measurements for 120 Normal Subjects (240 knees) and for a Group of Patients With a Chronic ACL Disruption. Frequency distribution: 30° of Knee Flexion. Reproduced with permission from Daniel, D.M., and Stone, M.L. 1990. Knee Ligaments: Structure, Function, Injury and Repair. Figure 24-8, New York: Raven Press.

patients who presented with acute hemarthrosis (presumed ACL tears), a KT-1000 criterion of >5 mm (20 lb. force) was useful in distinguishing "copers" from "non-copers" with a positive predictive value of 92% (Table VIII-6). Copers were participating in a running sport, had infrequent or no giving way episodes, and did not ask for an ACL reconstruction. Non-copers wished to have surgery. However, using the same data base, it appears that an alternative criterion of >7.5 mm difference with maximal manual force has a better sensitivity without significant loss of specificity (Table VIII-7).

TABLE VIII-6
Use of >5 mm Side-to-Side Difference on KT-1000 to Distinguish Between "Copers" and "Non-Copers" Following ACL Rupture (20 lb. Force)

	≤5mm	>5mm
Copers	37	6
Non-copers	64	65

Sensitivity = 50%
Specificity = 85%
Positive Predictive Value = 92%

Data from Daniel, D.M., and Stone, M.L. 1990. KT-1000 anterior-posterior displacement measurements. Chap. 24 in Knee Ligaments: Structure, Function, Injury, and Repair. eds. D.M. Daniel, et al. New York: Raven Press.

TABLE VIII-7
Use of >7.5 mm Side-to-Side Difference on KT-1000 to Distinguish Between "Copers" and "Non-Copers" Following ACL Rupture (Maximum Manual Force)

	≤7.5mm	>7.5mm
Copers	36	7
Non-copers	42	87

Sensitivity = 67%
Specificity = 84%
Positive Predictive Value = 93%

Data from Daniel, D.M., and Stone, M.L. 1990. KT-1000 anterior-posterior displacement measurements. Chap. 24 in Knee Ligaments: Structure, Function, Injury, and Repair. eds. D.M. Daniel, et al. New York: Raven Press.

2. MORE THAN MINOR WEAKNESS: Weakness of the hamstrings and quadriceps can be measured in a variety of ways. Two common quantitative techniques are:

- Isokinetic Machines Such as the "Cybex" or "Biodex": From a sitting position, the patient extends and flexes the knee as forcefully as possible while a mechanical arm attached to the ankle maintains constant angular speed. Force is measured as ft.-lbs. of torque at speeds which usually range from 60-300 degrees/sec. (Ironically, running involves angular speeds of much greater magnitude.) Numerous parameters, such as maximum torque, maximum work, and average work are measured, although there is no consensus as to which is more functionally relevant. Ninety percent or more of normal patients will have a side-to-side symmetry of at least 80% (Wyatt & Edwardo, 1981; Daniel, et al., 1982). Additionally, the ratio of hamstring to quadracep strength is normally around 80%.

- Hopping Tests: These are useful lower-limb functional tests that require a minimum of space, equipment, and time:

  a) Single Hop for Distance - The candidate stands on one limb, hops as far as possible, and lands on the same limb. The distance is measured and recorded. Each limb is tested two or three times, alternating between limbs.

  b) One-Legged Timed Hop - A distance of 6 meters is measured. The candidate is encouraged to use large forceful one-legged hopping motions in performing a series of hops over the total distance. A series of two tests are completed for each limb, with mean times calculated to the nearest one-hundredth of a second.

  Expected absolute values are a function of gender and level of sports participation. However, symmetry is unaffected by these factors. Normal symmetry is always ≥ 80% and is usually at least 85% (see Table VIII-8; Barber, et al., 1990). Daniel, et al. (1990) found that 95% of normals had a symmetry score of 90% in the single hop test.

The clinical significance of muscle weakness derives from the following considerations:

- The hamstring muscle can exert a posterior force on the tibia and, to a certain degree, plays a role in stabilizing the ACL-deficient knee (Solomonow, et al., 1987). Consequently, hamstring weakness is associated with a very poor prognosis. One study of unrepaired ACL patients found that the 56% (n=9) of those who manifested hamstring deficits >15% had poor results, compared to 36% (n=50) of patients with deficits of 15% or less (Bonamo, et al., 1990).

- Quadriceps weakness is also strongly associated with poor results Jarvinen & Kannus, 1987; Bonamo, et al., 1990). Although this muscle does not contribute to the stabilization of an ACL-deficient knee, weakness is a marker for common secondary complications such as pain, flexion contracture, and patellar irritability (Sachs, et al., 1989).

- Patients with abnormal hop tests are at very high risk of GW and having functional limitations during sports (Barber, et al., 1990; Noyes, et al., 1991). The major problem with these tests is low sensitivity: 50% if one test is performed, and 62% if two hop tests are conducted (using >15% asymmetry as a criterion for abnormal). However, specificity is very high (92-97%).

TABLE VIII-8
Limb Symmetry in One-Legged Hop Testing of Normal Patients

Limb symmetry index	Percent of normal patients	
	Hop for distance	Timed hop
.90	81%	71%
.85	93%	92%
.80	100%	100%

Reproduced with permission from Barber, S.D., et al. 1990. Quantitative assessment of functional limitations in normal and anterior cruciate ligament-deficient knees. Clin Orthop Rel Res. 205:204-214.

3. POOR EXERCISE HISTORY: The risk of developing GW or functional limitations is directly proportional to the extent of participation in stressful twisting, turning, and jumping activities (Finsterbush, et al., 1990; Holmes, et al., 1991; Noyes, et al., 1983). Therefore, denial of problems by a candidate must be discounted if such activities are avoided.

4. RECENT ACL TEAR OR REPAIR: The probability of developing recurrent GW and/or functional limitations appears to increase with time until perhaps 5 years after the tear has occurred (Table VIII-9). However, of those patients who request surgery within this time period, approximately 80% do so within 24 months of the original injury (Daniel, et al., 1992). Progressive deterioration may be due to recurrent injuries or the gradual stretching of secondary restraining structures, such as the medial and lateral capsules and the iliotibial track (Butler, et al., 1980). ACL reconstruction can apparently prevent this deterioration, as evidenced by multiple studies which indicate that stability is expected after 1 year post-op (Table VIII-9).

TABLE VIII-9
Development of Instability vs. Time

Author (n)	Observation Period	Change in Clinical Status During Observation Period
Unrepaired or Repaired Without ACL Reconstruction:		
Satku (55) 1986	Post-recovery vs. 6 yrs	27% not able to cope with same level of sports
Engebretsen (50) 1990	1 vs. 2 yr	Significant increase in prevalence of instability
Bray (45) 1988	1 vs. 3 yr	9% developed (+) pivot shift
Sandberg, et al. (57) 1987	1 vs. 3 yr	30% no longer "excellent"
Odensten (16) 1984	2 vs. 5 yr	38% became unstable
Feagin (32) 1976	2 vs. 5 yr	Prevalence of impairment with sports increased from 20% to 75%
Kaplan (52) 1990	2.5 vs. 7 yr	15% developed complaints of instability
Fetto (103) 1980	3 vs. 5 yr	Progressive deterioration observed over time period. By 5 yr, 85% of unrepaired knees rated as poor.
Bray (41) 1988	3 vs. 6 yr	37% developed objective instability
Sommerlath (45) 1991	3.5 vs. 12 yr	18% developed objective instability
Bonamo (30) 1990	4 vs. 8 yr	23% more patients had poor results
Noyes (103) 1983	<5 vs. >5 yr	Prevalence of GW increases slightly but not significantly
Repaired with ACL Reconstruction:		
Engebretsen (50) 1990	1 vs. 2 yr	No increase in prevalence of instability
Kochan (18) 1984	1 vs. 3 yr	No increase in instability
Howe (83) 1991	1 vs. 10 yr	No increase in failure rate
Harter (25) 1989	2.5 vs. 5 yr	No increase in instability

By careful consideration of these four risk factors for GW and functional disability, the evaluating physician can determine which candidates pose a direct threat if they were to perform patrol officer duties despite their denial of any current problems.

Special Note on Partial ACL Tears: The ACL ligament is composed of two major fiber bundles (antero-medial and postero-lateral) contained within a synovial sheath. A partial tear involving only one of these fiber groups is not uncommon and may appear as "intra-substance" bleeding on arthroscopy. This injury is frequently misdiagnosed as a meniscal tear due to complaints of locking and pain rather than instability (Farquharson-Roberts & Osborne, 1983; Finsterbush, et al., 1989). Although studies indicate that many patients with a partial tear do well with conservative care, there is a substantial risk of progression to complete tear (Table VIII-10). A recent study found that this risk was directly proportional to the amount of the tear: 86% of 3/4 tears and 50% of 1/2 tears progressed to full tears at follow-up 24-110 months later (Noyes, et al., 1989). One-quarter tears were much less likely to progress.

This study also found that other risk factors for progression included initial AP laxity and subsequent reinjury. In the group of 32 patients studied, 56% were reinjured within two years after the initial injury.

Special Note on the Use of Derotational Braces: These are often prescribed for a period of time after surgery, or as part of a conservative care regimen. Although they can reduce the risk of GW, they do not eliminate it. For example, Bonamo, et al. (1990) found that bracing reduced the prevalence of GW from 47% to 23% during sports participation in patients with unrepaired ACLs (Bonamo, et al., 1990). Moreover, it would be quite difficult to ensure that an officer is wearing the cumbersome brace at all times while on duty, particularly since it becomes uncomfortable with prolonged sitting or driving and would need to be worn on top of the uniform. Given these considerations, use of a derotational brace cannot be considered a reasonable accommodation.

TABLE VIII-10
Partial ACL Tears

Clinical Significance	
Buckley, 1989	40% fair-poor results 56% did not engage in pre-injury sports (N=25; follow-up = 4 years)
Kannus, 1987	33% did not engage in pre-injury sports 7% had to change occupations due to knee 15% had three or more reinjuries 68% had anterolateral instability on exam (N=41; follow-up = 8 years)
Odensten, 1985	All had at least good results (N=21; follow-up = 6 years)
Risk of Progression to Full Tear	
Sandberg & Balkfors, 1987	62% of 29 patients initially stable during anesthesia exam found to have instability 12-60 months later
Finsterbush, 1990	26% of 42 patients progressed to full tear within 4 years
Odensten, 1985	14% of 21 patients stable at 21 months developed instability by 70 months
Noyes, 1989 (c)	38% of 32 patients progressed to full tear at 24-110 months follow-up

b. RECOMMENDED EVALUATION PROTOCOL:

Carefully question candidates with a history of ACL tear about symptoms of pain, swelling, and instability. Those with partial tears should be asked specifically about locking. Details regarding surgery, physical therapy, and use of braces must be carefully ascertained. Inquire about pre-injury and post-injury sports participation. Determine why the candidate did not return to pre-injury status.

Medical records, including any operative reports should be reviewed.

The physical examination of both knees should include the following (in addition to that outlined in General Screening Recommendations):

- Lachman test
- Anterior drawer
- Pivot shift (preferably performed by an orthopedist)
- Range of motion (candidates should not have a flexion deformity of 10 degrees or limitation of flexion to <120 degrees. Note: these candidates need to see an orthopedist for manipulation - Mohtadi, et al., 1991).

Radiographs, including a lateral, standing AP, and a 45 degree patellar view (Merchant, et al., 1974), should be obtained.

Ancillary testing, such as arthrometer and isokinetic muscle testing, should be obtained whenever possible.

Evidence that a candidate is either at substantially increased risk of sudden incapacitation during a critical incident or may have significant functional impairment (despite denial of any problems) would include any of the following findings:

1. <u>More than Minor Instability</u>: >5 mm side-to-side difference on 20 lb. KT-1000 test, >7.5 mm side-to-side difference on maximum manual KT-1000, 2+ Pivot shift, or 2+ Anterior drawer;

2. <u>More than Minor Weakness</u>: Hop test, quadriceps, or hamstring asymmetry >15%;

3. <u>Poor Activity History</u>: Acceptable candidates should have a 1-2 year recent history of successful high-level, high-risk sports participation.

4. <u>Recent Tear or Repair</u>:

    - <u>S/P ACL Reconstruction</u>: Candidates should be restricted from engaging in foot pursuits for at least 12 months after surgery.

    - <u>History of Partial Tear</u>: Candidates should be restricted from engaging in foot pursuits for a minimum of 6 months - 2 years after the original injury or most recent episode of GW depending on the extent of the tear.

    - <u>Full Tear Unrepaired or Repaired without ACL Reconstruction</u>: Candidates should be restricted from critical incidents requiring running, cutting, and jumping for a minimum of 2-5 years after the original injury or most recent episode of GW.

10) COLLATERAL LIGAMENT INSTABILITY

Isolated complete tears of the medial collateral ligament (MCL) do not require surgery and, in general, have a benign prognosis. This has been observed even in injured football players (Jones, et al., 1986; Indelicato, et al., 1990). However, when there is concomitant anterior cruciate laxity, the prognosis is poor. For example, one follow-up study of 27 patients found that most had symptoms and muscle weakness (Kannus, 1988).

Candidates with a history of MCL tears should be carefully examined for AP laxity and thigh atrophy. If the candidate is asymptomatic, has no cruciate laxity or significant thigh atrophy (>1/2"), no restrictions can be justified, even if residual MCL laxity to valgus stress is present. In these cases, radiographs and record review are not necessary.

The evaluation of candidates with tears of the lateral collateral ligament (LCL) is similar to that of MCL deficient candidates. Although this injury is quite uncommon and therefore fewer studies exist, several suggest that the prognosis for partial tears (grade II) is very good (Ellsasser, et al., 1974; Kannus, 1989). However, complete tears (grade III) are often associated with cruciate damage, and in these cases the prognosis is particularly poor (Kannus, 1989).

11) ACROMIOCLAVICULAR (AC) SEPARATION

There are two common classifications of AC injuries, one developed by Tossy, et al. (1963) and the other by Allman (1967). Table VIII-11 describes these two classification schemes.

TABLE VIII-11
Classification of Acromioclavicular Injuries

Type of Grade	Allman (1967)	Tossy (1963)
I	Acromioclavicular ligament sprain; joint stable; normal x-ray films acutely	No gross deformity
II	Acromioclavicular ligament and capsule torn; coracoclavicular ligaments stretched but intact; x-ray elevation of clavicle less than width of clavicle	Distal clavicle displaced up to one half of the normal superior-inferior height of joint as compared with normal side
III	Same injury as grade II plus tear of the coracoclavicular ligaments; x-ray elevation of clavicle above superior surface of acromion	Separation of joint greater than 1/2 of its normal height, with wide separation of the coracoclavicular relationship

Reproduced with permission of Wickiewicz, T.L. 1983. Acromioclavicular and sternoclavicular joint injuries. Clinics Sports Med. 2(2):429-437.

Candidates with a history of Grade I or II separations within the last several months should be deferred until they are asymptomatic, non-tender, and have a normal range of motion with full strength for at least one month. A thorough history, examination, and record review is important to identify the estimated 8% of Grade I and 13% of Grade II patients who suffer persistent, significant symptomatology (Cox, 1981).

Candidates who have recently suffered a Grade III injury should be deferred for at least three months from the date of injury and for at least one month after the resumption of full activity to eliminate the majority of those who will do poorly and require surgery (Taft, et al., 1987). At that time, the candidate should be carefully questioned regarding recent symptoms, especially with heavy loads, since an estimated 25% will have difficulty due to residual pain (Dias, et al., 1987). Candidates with pain, weakness, tenderness, or a significantly decreased range of motion should be deferred until evaluated by an orthopedist.

Candidates with remote histories of AC separation require a thorough history and examination. In general, evidence of persistent Grade III separation is not of concern if the candidate is asymptomatic, the examination is otherwise negative, and there is no history of pain lasting more than 3 months within the last year.

Forty-five percent of patients with AC separations will have some evidence of radiographic degenerative disease, but these changes are generally poorly correlated with symptomatology (Taft, et al., 1987; Smith & Stewart, 1985). Therefore, radiographs are not helpful from a prognostic perspective. However, they may be useful to establish a baseline for future workers' compensation purposes. In certain cases, radiographs may also help one distinguish between a history of AC separation and a shoulder dislocation.

12) SHOULDER SUBLUXATION AND DISLOCATION

a. GENERAL CONSIDERATIONS:

The shoulder joint is a highly mobile structure whose stability depends on a complex interaction between static stabilizers, such as the glenoid labrum and the glenohumeral ligaments, and the dynamic forces of the surrounding musculature which compress the head of the humerus into the glenoid fossa. Clinically, however, instability is most commonly associated with tearing of the labrum. Subsequent subluxation and dislocation may be uni- or multi-directional, but usually occurs anteriorly. In these patients, the joint is most unstable when the arm is stressed in an externally rotated and fully abducted overhead position. Only anterior instability will be discussed in this section.

Patients with mild anterior subluxation may only complain of mild pain (Warren, 1983). This is related to inflammation within the rotator cuff and capsule due to abnormal traction placed on these tissues. Those with more severe instability are aware of episodes of subtle movement of the shoulder in and out of the socket, and complain that they do not "trust" the shoulder (Simonet & Cofield, 1984). Often these episodes are associated with a severe transient pain that shoots down the arm which may go "numb" or "dead." The sensation will gradually clear after several minutes, but will be followed by feelings of weakness (Warren, 1983).

In anterior dislocations, spontaneous relocation does not occur, and there is total loss of use of the arm. Patients with a history of dislocation may also complain of symptoms consistent with intermittent subluxation.

Since both subluxation and dislocation can cause sudden incapacitation of an officer, the physician must determine which candidates are at a significantly increased risk of recurrence during activities such as wrestling combative arrestees or climbing walls.

SUBLUXATION: Risk assessment of candidates with subluxation is made somewhat difficult due to a lack of prospective studies. Typically, mild instability only causes pain with repetitive motion activities (such as weight training). It is not known how many of these patients will progress to suffer the symptoms of more severe instability described above. Furthermore, the prognosis of patients who already have incapacitating arm symptoms is also unknown. These patients are treated with physical therapy to strengthen the internal and external rotators to a level equal to 20% of body weight (Matsen & Zuckerman, 1983), but there are no studies that document the long-term effectiveness of this treatment.

Given this lack of knowledge and the potential for injury to others, the physician must assess relative instability by looking for the following clinical signs. Unfortunately, these signs are often not present even with a history of dislocation.

- Apprehension Sign: The arm of the relaxed, supine candidate should be abducted to 90 degrees and progressively extended and externally rotated with gentle but persistent pressure over a number of minutes. A positive sign is evidence of apprehension or subluxation.

- Hill-Sachs' Lesion: This cortical impression fracture of the posterolateral humeral head is caused by the edge of the glenoid during dislocation (Hill & Sachs, 1940). Scapular anteroposterior and axillary view radiographs should be obtained.

If either of these signs are present, the candidate has more than mild instability and is at increased risk of dislocation. This risk warrants a period of observation before clearance for full duty.

DISLOCATION: The prognosis for recurrence is generally very high unless surgery is performed. Published longitudinal studies have identified several factors that are relevant:

- Activity Level: Dislocation is associated with physical trauma or athletic participation in about 90% of cases (Hovelius, et al., 1983; Hovelius, 1987). In the remaining 10% of cases, the dislocation occurs with movement that a normal shoulder should tolerate. However, the degree of trauma associated with the first dislocation is not a prognostic factor for future recurrences (Hovelius, 1987).

- Radiographic Abnormalities: Evidence of fracture of the greater tuberosity of the humerus on the original radiograph indicates a very low to non-existent probability of recurrence (Hovelius, 1987; Rowe & Sadellarides, 1961). This lesion is found in about 8% of patients <30 years old and in about 20% of those older. Absence of a Hill-Sachs' lesion indicates a somewhat improved prognosis, but has limited use since 11-71% of these patients (depending on age) will have a recurrence within 5 years (Hovelius, 1987).

- Age: Numerous studies (e.g. Hovelius, 1987; Simonet & Cofield, 1984) have documented that age is the most important risk factor for recurrence (although most did not control for activity level). It appears the glenohumeral joint is inherently more lax in younger persons. This is evident from an observation by Hovelius (1987) that primary dislocation occurred spontaneously without trauma in 14% of patients <23 years old, compared to 5% of those 23-29 years old, and 1% of patients 30-40 years old.

  Several studies have found recurrence rates in the range of 60-90% in patients <30 years old (Rowe, 1956; Rowe & Sadellarides, 1961; Henry & Genung, 1982; Simonet & Cofield, 1984). However, the best study for risk assessment purposes is that by Hovelius (1987). This study is unique in that it was prospective, all patients had the same length of follow-up (five years), it was the largest published series of primary dislocation in patients age 40 or less, and the drop-out rate at follow-up was less than 1%. Tables VIII-12-14 were derived from this study.

  Table VIII-12 shows the percent of patients in three age groups who experienced at least one recurrence after five years of follow-up. The rate decreases from 69% in patients <23 years old to 25% in those 30-40 years old. Some patients may not experience another dislocation, but complain of instability due to subluxation. When these patients are added to those who have redislocation, the total percentage of patients who have continuing problems increases to 72% in the younger and 36% in the older group (Table VIII-13).

TABLE VIII-12
Percent of Patients Who Experience at Least One Recurrence of Anterior Dislocation by Age and Years of Follow-Up*

Age	Two Years	Five Years
12-22 (N=94)	51%	69%
23-29 (N=55)	31%	51%
30-40 (N=76)	16%	25%

*Cases with tuberosity fractures were excluded.
Data from Hovelius, L. 1987. Anterior dislocation of the shoulder in teenagers and young adults. J Bone Jt Surg. 69A:393-399.

TABLE VIII-13
Percent of Patients Who Experience at Least One Recurrence of Anterior Dislocation or Subjective Instability by Age and Years of Follow-Up*

Age	Two Years	Five Years
12-22 (N=94)	67%	72%
23-29 (N=55)	53%	62%
30-40 (N=76)	30%	36%

*Cases with tuberosity fractures were excluded.
Data from Hovelius, L. 1987. Anterior dislocation of the shoulder in teenagers and young adults. J Bone Jt Surg. 69A:393-399.

- Time Since Last Recurrence: Most patients who will have a recurrence will do so within two years (Hovelius, 1987; Simonet & Cofield, 1984). However, a substantial proportion of patients doing well after two years will have recurrence by five years of follow-up (see Table VIII-14 derived from Hovelius, 1987).

TABLE VIII-14
Percent of Patients With No Dislocation Recurrence at Two Years of Follow-Up Who Experience at Least One Recurrence After Three Additional Years of Follow-Up*

Age	Number without recurrence after two years	Percent who dislocate by five years
12-22	46	37%
23-29	38	29%
30-40	64	9%

*Cases with tuberosity fractures were excluded.
Data from Hovelius, L. 1987. Anterior dislocation of the shoulder in teenagers and young adults. J Bone Jt Surg. 69A:393-399.

It is clear that a two-year deferral period would not be sufficient to consider a candidate "cured" regardless of age. Considering even five-year survivors as cured is questionable, given the substantial dislocation rates between two and five years. However, 98% of patients who ultimately have surgery have their first recurrence within five years after the initial dislocation (Hovelius, et al., 1983). Based on this consideration and the lack of follow-up data beyond a five-year period, it is reasonable to consider candidates who are 40 years old or younger at the time of the initial dislocation to be at substantial risk until five years have elapsed since their last dislocation.

For patients who are older than 40 years at the time of their first dislocation, the recurrence rate is substantially reduced. Simonet and Cofield (1984) did not observe any redislocation in a group of 41 patients followed from 2-4 years. However, 12% had unsatisfactory results due to symptomatic instability. These data would support a deferral period of two years for these candidates.

- Conservative Treatment: Conservative treatment consists of immobilization in a sling for a few weeks followed by physical therapy.

  Hovelius (1987) showed that immobilization for 3-4 weeks did not reduce the rate of recurrence. However, there is some data which suggests that longer immobilization improves the prognosis, but does not provide a "cure" with any certainty (Simonet & Cofield, 1984; Near & Welsh, 1977). For example, Simonet and Cofield (1984) found that six weeks of restriction from full activity decreased probability of "unsatisfactory" results from 85% to 44%.

  Patients with instability appear to have lower internal rotator strength in their shoulders as compared to normals (Warner, et al., 1990). However, Simonet and Cofield (1984) found that those referred to physical therapy after a dislocation did not have better long-term results. Warren's (1983) overall impression is that "exercise will benefit some patients with subluxation but is not helpful in dislocation." Aronen and Regan (1984) claimed that while rehabilitation decreased recurrence rates, 28% of a young cohort still required surgery after five years of follow-up. Thus, muscle development has not been shown to prevent recurrent dislocation with any certainty.

- Number of Recurrences: If a patient has had one recurrence, the risk of another is substantially increased. For example, in the Hovelius study (1987), 12/19 patients had another dislocation within three years, and five of these patients requested surgery. After two recurrences, 25/31 patients had another dislocation within three years, and seven of these requested surgery. Simonet and Cofield (1984) similarly observed that no patient with two recurrences had a satisfactory result.

- Surgery: The several procedures effective in stabilizing the shoulder all have associated complications. Nearly all patients will have some loss of abduction and external rotation. Post-operative subluxation or dislocation occurs in up to 13% of patients, depending on the procedure and the activity level of the patient (Miller, et al., 1984; Collins, et al., 1986; Hovelius, et al., 1983; Protzman, 1980). Moreover, between 18-35% of post-operative dislocations occur more than two years after surgery (Morrey & Janes, 1976; Rowe, et al., 1978). Given these considerations, it is not unreasonable to defer these candidates until completion of at least a 2-3 year uneventful post-surgical period.

In evaluating these candidates, a final consideration may be the presence of severe degenerative joint disease. Recent research suggests that degeneration of the joint will occur within 10-15 years, even with surgical stabilization. Although not a risk factor for dislocation or sudden incapacitation, these candidates may be at a substantial risk of disability from the unavoidable trauma of shotgun recoil forces and wrestling.

b. RECOMMENDED EVALUATION PROTOCOL:

Candidates with a history of subluxation should be specifically questioned regarding any symptoms referable to the arm, such as pain, numbness, or weakness. Examination should include testing for apprehension (see above). Radiographs should include A-P and axillary views.

Those with a history of dislocation should be questioned regarding dates of occurrences, treatment, and subsequent symptoms of instability. Some candidates will report a history of acromioclavicular separation when asked about dislocations. A careful history and having the candidate point to the location of pain will usually clarify the diagnosis. If doubt remains, a radiographic series may show a Hill-Sachs' lesion. To avoid unnecessary radiation to candidates with dislocations, radiographs should be deferred until it has been determined that the candidate is otherwise qualified. In these cases, the radiograph is then used to examine the condition of any post-surgical hardware and to determine the extent of degenerative changes.

Record review is strongly recommended for both groups of candidates. In candidates who have had only one dislocation, an attempt should be made to obtain any radiographs taken at the time of dislocation to determine if a tuberosity fracture was present.

<u>HISTORY OF SUBLUXATION ONLY</u>

GROUP I: NO HISTORY OF ARM PAIN OR WEAKNESS, NEGATIVE APPREHENSION SIGN AND NO HILL-SACHS' LESION ON RADIOGRAPHS

In general, no restrictions are warranted. However, the physician may want to consider whether a candidate with subluxation will be able to tolerate any weight training required in the academy.

GROUP II: HISTORY OF ARM PAIN OR WEAKNESS, OR POSITIVE APPREHENSION SIGN, OR HILL-SACHS' LESION ON RADIOGRAPHS

To substantially reduce the risk of sudden incapacitation, these candidates should be restricted from wrestling and overhead activities for a period of two years from the date of their last episode of arm symptoms. The presence of an apprehension sign or Hill-Sachs' lesion should warrant an observation period of two years to substantially reduce the risk of sudden incapacitation.

HISTORY OF ANTERIOR DISLOCATION

GROUP I: FRACTURE OF THE GREATER TUBEROSITY PRESENT ON FILMS OF PRIMARY DISLOCATION

No restrictions or deferral is warranted if the candidate is otherwise doing well and has been asymptomatic for one year.

GROUP II: PRIMARY DISLOCATION AT AGE >40, OR S/P SURGERY (ANY AGE)

To substantially reduce the risk of sudden incapacitation, these candidates should be restricted from wrestling and overhead activities for a period of two years from the date of their last dislocation or surgery.

GROUP III: PRIMARY DISLOCATION FIRST OCCURRING AT AGE <40

To substantially reduce the risk of sudden incapacitation, these candidates should be restricted from wrestling and overhead activities for a period of five years from the date of their last dislocation.

13) FINGER AMPUTATIONS/ARTHROSIS

These conditions are not uncommon among patrol officer candidates. The physician must assess whether the candidate's ability to tightly grip and handle either a baton or firearm would be significantly impaired, since an officer's life may depend on the ability to resist firearm take-away.

In many cases, the physician will be able to make this determination after examination. Amputations that do not extend beyond the distal interphalangeal joint will usually not cause impairment. Objective testing of grip strength with a dynamometer, such as the "Jamar," is also helpful. Although a guideline for minimum grip strength is unavailable, the physician can confidently clear someone if strength is symmetrical after considering hand dominance (± about 10%).

In cases where there is some question as to the significance of objective weakness or deformity, the physician should recommend that the hiring agency arrange a special handgun and baton handling assessment by the training academy, with final determination made by the appropriate professionals.

14) RETAINED HARDWARE

An assortment of screws, pins, nails, and plates are often used in orthopedic surgery. In many cases, controversy exists regarding when and whether retained hardware should be removed. Although patients and orthopedists may wish to avoid another procedure, removal may be indicated by migration into joint spaces. Similarly, palpable hardware may increase the risk of serious skin breakdown with minor trauma.

For these reasons, the physician should physically examine and obtain a radiograph of the area in question. If the hardware is palpable or there has been migration into a joint, an orthopedic opinion regarding the necessity of removal should be obtained. The candidate should be required to comply with this recommendation.

15) <u>LEG LENGTH DISCREPANCY</u>

a. GENERAL CONSIDERATIONS:

A difference in leg lengths of 1" or more should theoretically cause asymmetrical torsional stress on the L5 disc (Wiltse, 1971). However, large population studies do not show an increased incidence of back pain unless the discrepancy is more than 1.7" (Hult, 1954). To a great extent, the clinical significance of a leg length discrepancy depends on the height of the individual. For example, a 1" difference may be of little concern for a tall person for whom it represents a small percentage of the total length of the limb, whereas for a short person, it may be associated with an unacceptable limp and backache (Friberg, 1983). Another factor is whether the leg shortening occurred secondary to fracture in adulthood. These patients are more likely to have back pain than those with congenital shortening.

b. RECOMMENDED EVALUATION PROTOCOL:

Leg lengths should be measured if there is a history of back problems or an obvious pelvic tilt. Candidates with a leg length difference of 1" or more should be required to obtain a shoe-lift from a podiatrist or physician before being passed. It would be prudent to emphasize the importance of using the lift to the candidate to increase the chances of compliance.

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